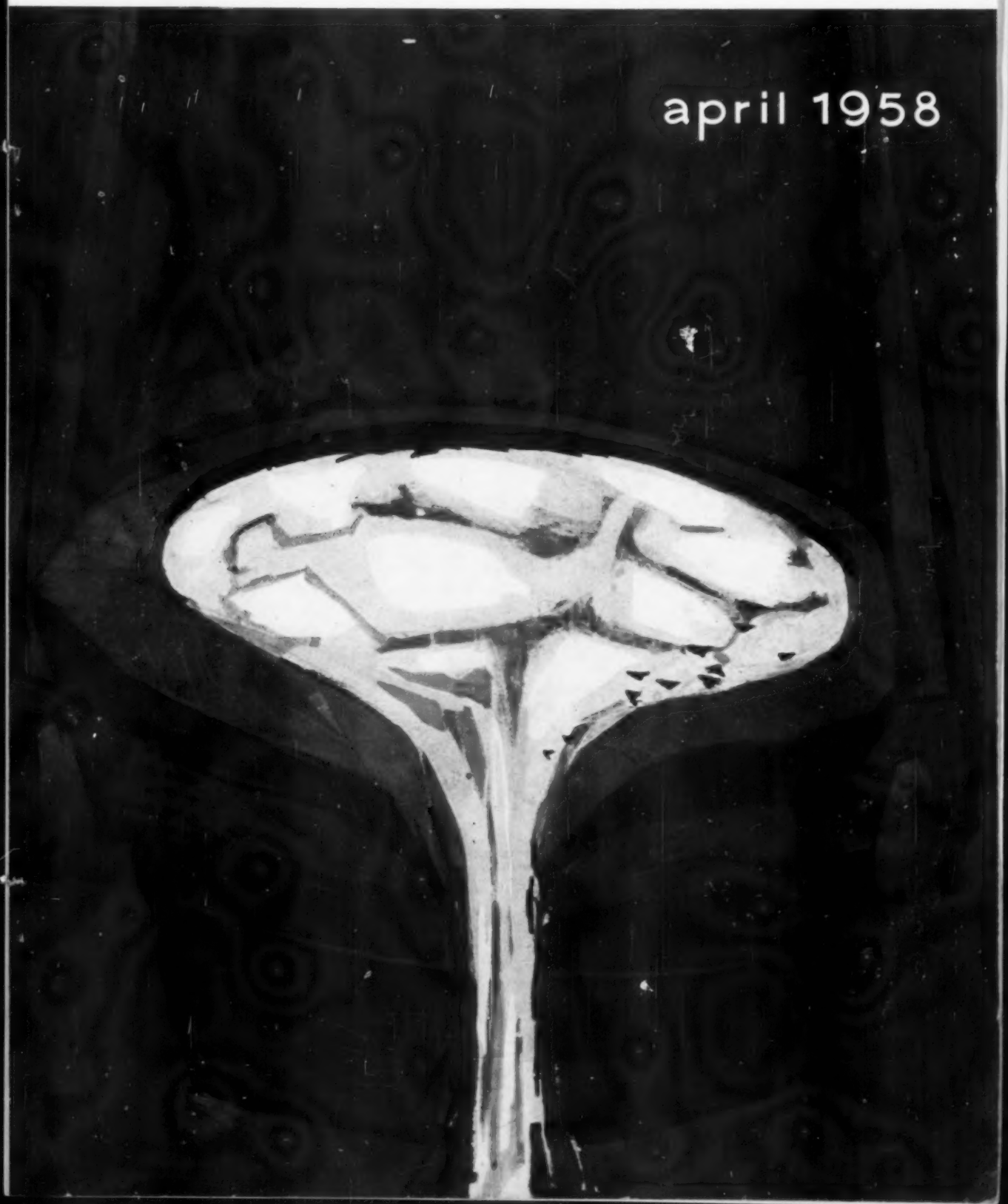
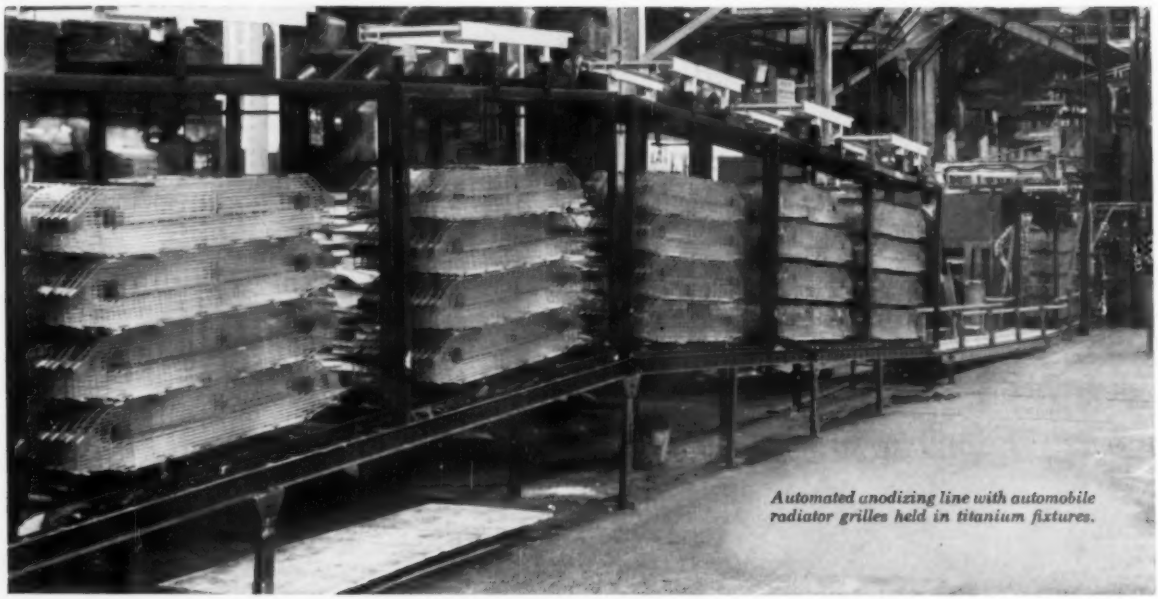
metal progress

april 1958



Progress with **TITANIUM**

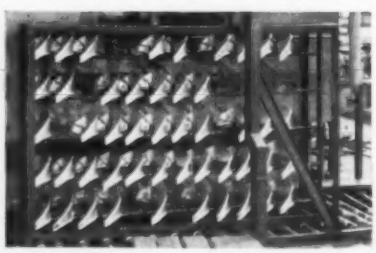


Automated anodizing line with automobile radiator grilles held in titanium fixtures.

TITANIUM LASTS 20 TIMES LONGER

in this anodizing process

Close-up of moldings held in titanium tips on anodizing rack.



Headlight assemblies held in titanium fixtures.

This automatic anodizing line at Reynolds Metals Company, Louisville, Kentucky, handles aluminum automotive parts on a huge scale. Parts such as window frames, grilles, hood moldings and headlight assemblies, are mounted on racks, which are first dipped in a brightener solution (highly concentrated sulfuric and phosphoric acid), then into an electrolytic bath.

What metal should be used to make the racks? Typical rack life at Reynolds was only 6 days on one anodizing line until titanium was tried. Average rack life is now *120 days.*

For economy in construction, the basic racks are made of aluminum, which is rubber coated. The rack tips or holding fixtures, which must be left bare, are made of Mallory-Sharon commercially pure titanium, riveted or welded in place.

Titanium in this mass production operation yields substantial savings, prevents the disruption of constant replacements. Let us help *you* evaluate titanium wherever you have the problem of corrosion. Write for booklet listing titanium corrosion-resistance data.

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Metal Progress

Volume 73, No. 4

April . . . 1958

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Cover by JACK JOHNSON, prizewinner in annual Competition at Cleveland Institute of Art

Engineering Articles

Ultrasonic Welding – a New Technique, by J. Byron Jones 68

Ultrasonic welding unites similar or dissimilar metals by introducing vibrational energy into the area to be joined. Solid-state metallurgical bonds, comparable in strength to those resulting from conventional methods, are produced. Thin gages, even in high-temperature, corrosion resistant metals, are readily welded. (K6r)*

The R-N Process for Direct Reduction of Iron Ores, Staff Report 73

This advanced process economically produces iron concentrates which are suitable as feed for blast furnaces, cupolas, openhearths and electric furnaces. It can be used for treating low-grade ore or with high-grade ore to produce metallics. Full sized plants have been designed and indications are that the combination of an R-N plant with electric furnaces would in many cases be cheaper to operate and involve less investment than a blast furnace-openhearth combination. (D8j, D5g, D1h; Fe, RM-n)

Selection of Steels for Springs, by H. J. Elmendorf 80

The mechanical properties of spring wire and springs are related; by knowing the wire tensile strength, the spring design stress can be predicted and the proper spring steel can be selected. (Q21, Q23b, Q27a; ST, SGA-b)

Semicontinuous Casting of Beryllium Copper, by K. G. Wikle 85

Billets in large and small size are cast with high yield of sound, fine-grained metal, free from residual beta phase, and at a lower cost per pound than by the conventional Durville process. (C5q; Cu, Be, 4-52)

Stress-Free Nickel Plating, Staff Report 90

Nickel in stress-free condition or with compressive stress can be plated from a sulphamate bath. It is finding a number of engineering applications on parts plated to improve fatigue life and minimize fretting and wear, and in electroforming to avoid distortion. It holds promise for improved high-temperature coatings for missiles and rockets. (L17a, Q25; *Ni*)

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METAL PROGRESS is published monthly by the AMERICAN SOCIETY FOR METALS. Publication office, Mt. Morris, Ill. Editorial, executive and advertising offices, 7301 Euclid Ave., Cleveland 3, Ohio. Subscription $7.50 a year in U.S. and Canada; foreign $10.50. Single copies $1.50; special issues $3.00 . . . The A.S.M. is not responsible for statements or opinions in this publication.

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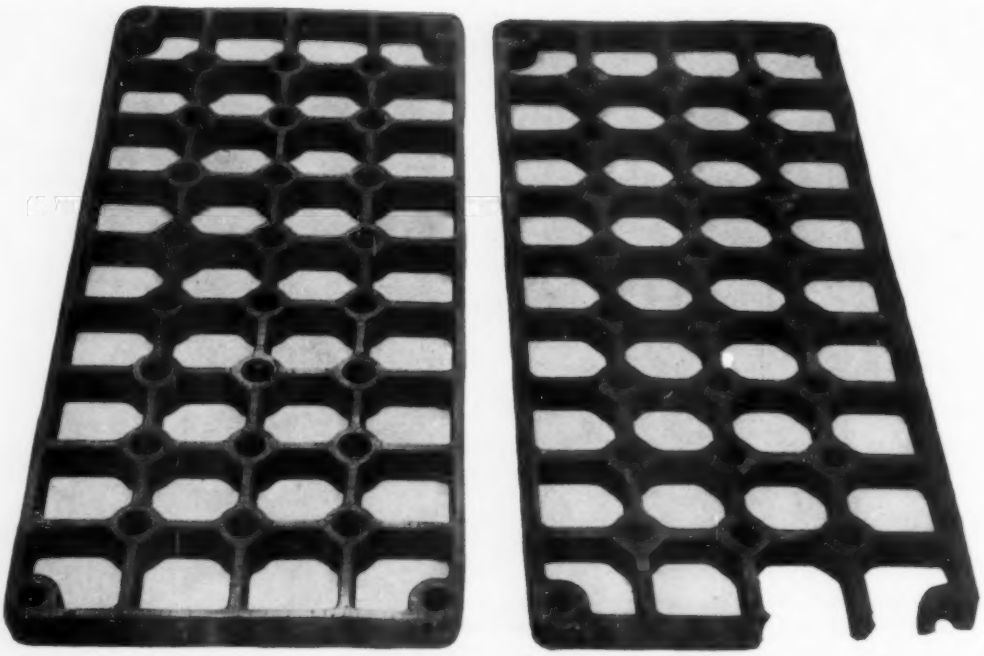
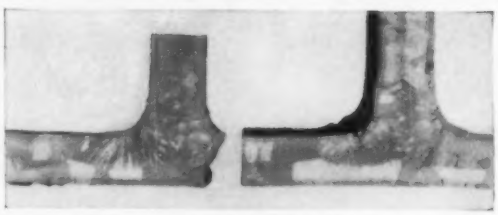
THE TALE OF TWO TRAYS





THERMALLOY TRAY—hot acid etch made after removal from service. Note that through proper chilling and foundry practice, most cracks are superficial.

COMPETITIVE TRAY—hot acid etch after failure shows severe shrinkage and cracking. This tray was in service *less than half* as long as the Thermalloy tray.

THERMALLOY* QUENCH TRAY
GIVES TWICE THE SERVICE LIFE

At a major automotive plant, two sets of quench trays were recently ordered for carburizing shafts at 1650 F. Both were of standard design. One set was cast by Electro-Alloys of Thermalloy heat-resistant alloy—the other was a competitive make.

The illustrations above clearly show the condition of the two test trays . . . after the Thermalloy trays had been in service *more than twice as long* as the competitive make. Use of chills at critical points and proper foundry technique in the Thermalloy trays accounted for their much longer service life . . . by eliminating the shrinkage evident in the competitive tray. This test, made by the customer, clearly proved the added quality and strength achieved through the use of chills.

Whatever *your* heat-treat problem, it pays to make use of Electro-Alloys casting know-how—plus the outstanding physical properties of Thermalloy high-heat-resistant alloys.

For further technical information on Thermalloy Heat-Treat Trays, write for Bulletin T-227 . . . Electro-Alloys Division, 9034 Taylor Street, Elyria, Ohio.

*Reg. U. S. Pat. Off.

AMERICAN Brake Shoe COMPANY **ELECTRO-ALLOYS DIVISION** Elyria, Ohio

Metallurgy of Tempering and Annealing in Fractional Minutes, by R. K. Wuerfel 93

Conditions for annealing nonferrous metals and tempering steels can be put on master curves. Tests were made to show that the optimum time for annealing or tempering by fractional-minute induction heating can be calculated. (J2g, J23, J29, 3-67)

Zone Melting Opens New Horizons in Metallurgy, Staff Report 97

Zone melting is fast developing into an important method for metal purification. It also has other uses in research, development and manufacturing. For example, it can distribute an impurity uniformly throughout a single crystal – a problem long unsolved. Purpose of this article is to tell what can be done with zone melting, not precisely how to do it. (C28k)

Tear Test for Titanium Sheet, by C. W. Vigor and J. R. Hornaday, Jr. 103

Small coupons are torn by a conventional tensile testing machine. The amount and duration of applied force are recorded and used to determine the work required for tearing. Resulting data measure effect of hydrogen embrittlement, and thermal instability. (Q26q, Q26s, 1-54; Ti, *H*)

Cermets in Jet Engines, by J. W. Graham and W. F. Zimmerman 108

Despite the extensive experimental work in the last ten years, cermets, because of their inherent low impact strength, have not proved suitable for jet engine components. Since substitutes with the needed properties have become available, research work on cermets is now confined to basic principles. (T7h, 17-57; SGA-h, 6-70)

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Revised curves issued by American Iron and Steel Institute, March 1957.

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A Manganese Steel Data Book, Reviewed by D. N. Rosenblatt 106

"Manganese Steel", prepared by the staff of Hadfields Ltd. of Sheffield, England, is an exhaustive exposition directed more toward application than theory.

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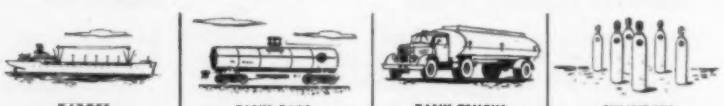

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As I was saying...

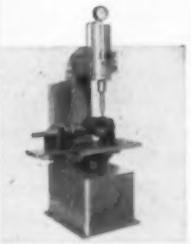
It sure was a wonderful meeting – the gathering at the Union Club in Cleveland on March 6, when 125 newspaper, radio and television reporters, editors, architects, monthly and weekly news and trade publications, together with a distinguished and representative group of Cleveland's top industrialists, had presented to them the artist's wash drawing of the headquarters building of the A.S.M. of Tomorrow.

It was a great thrill as well as an anxious moment as the beautiful colored slide of the building was projected on the screen. What will its reception be? You know it pleases you but what will others say and think? You've been so close to the whole project. Perhaps you are hypnotized – but now, the lights are out, the guests are hushed in silence and expectation, the first building of the A.S.M. of Tomorrow flashes on the large screen. You hear the oh's and ah's, then there comes to your ears a most pleasant sound – the thunderous applause of viewers. You relax at once and thrill to the thought that the design by the young architect, John Kelly, which was approved by the Board, the staff and consultants, has also now received the accolade of a most critical audience.

So it was indeed a most happy meeting for all of us. The guests assembled at noon and the reception continued until 12:25, when luncheon was served. Then all relaxed and sat back at ease when I tapped the bell and introduced Vice-President Lorig and President Young, who gave a pointed report of the preliminary studies and investigations relative to the selection of the site for the building and the needs of the additional space to consolidate the 99 members of the staff now distributed among five buildings in the city. In closing, Mr. Young introduced the Secretary – to give some background information regarding the A.S.M. and also the A.S.M. of Tomorrow. You know how I enjoy talking, and since I was requested to talk about my favorite subject, I let 'em have a full ten minutes of it. I finished with presenting (*Continued on p. 6*)

Secretary Eisenman and Architect John Kelly With the Wash Drawing of the Headquarters Building Unveiled March 6

will any of these tests help you?



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As I was saying...

on the screen the full colored slide of the architect's vision of the building.

After the applause (for the beautiful and unusual design) I introduced John Kelly, the architect, who spoke of the relationship of the design to the garden setting, about the wonderful opportunity that had come to him so early in his career to design a building representing a great technical society in such beautiful surroundings – and that he was blessed with a cooperative and enthusiastic client and a forward-looking contractor.

Then came a few well chosen words from Alan Gillmore, Jr., of the building firm, reporting the great excitement the building had created in his organization and their pleasure in being a participant in its creation.

It was then my pleasure to present R. Buckminster Fuller, president, Synergetics, Inc., the inventor and designer of the geodesic dome. "Buck", as he is affectionately called, then told of the first A.S.M. meeting he attended in New York, at which the strength of structures was discussed. He praised the developments and contributions to materials by the metallurgist. His presentation was especially well received and he congratulated Architect John Kelly on his use of the "space lattice" geodesic dome, saying "that is both prophetic of the trend toward invisibility and appropriately celebrates the awareness of metallurgical science, of its ultimate kinship to geodesic construction because of the synergetic integrity of both."

I then announced that "press kits" were available on departure and thanked our friends for coming to the luncheon and press conference.

From time to time we'll give you, in *Metal Progress* and *Metals Review*, the remarks by the participants so you will know how they feel about the project.

I'm glad to tell you of this successful meeting. It gave joy to all of us and I know you also will be happy for the reams of publicity and acceptance your first building received.

Cordially yours,

Bill

W. H. EISENMAN, *Secretary*
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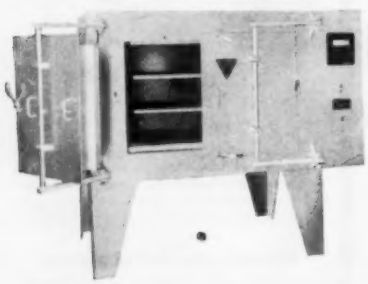

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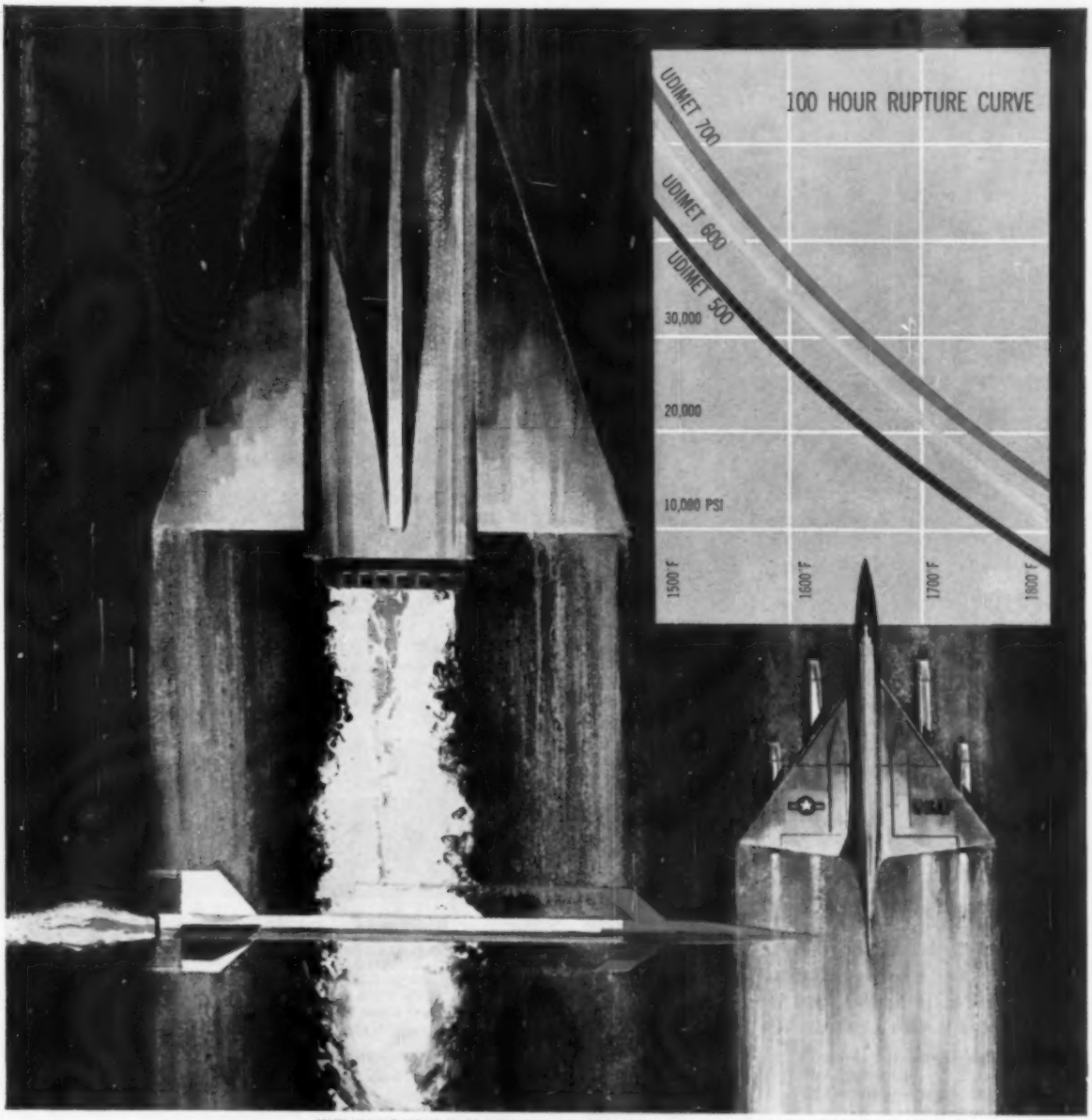

MANY VACUUM INDUCTION MELTED METALS AND ALLOYS CAN NOW BE PRODUCED IN HEAT SIZES UP TO 5,000 LBS. BY UTICA METALS DIVISION

announcing Udimet 600 and 700

for a wider range of applications at elevated temperatures!

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Like Udimet 500, Udimet 600 is now available in production quantities. Udimet 700 is available for development applications. Write for complete information.

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- Greater impact resistance
- Greater creep properties

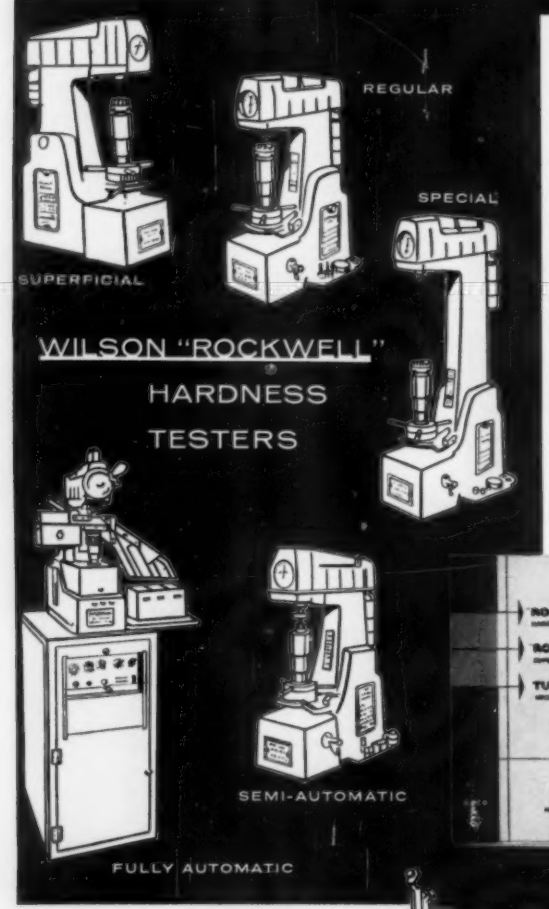
UTICA METALS DIVISION OF **KELSEY-HAYES**

KELSEY-HAYES CO. U DI MET® ALLOYS UTICA 4, NEW YORK

®T. M. REGISTERED

SOME ALLOYS COVERED BY U. S. PATENT #2809110

WILSON "ROCKWELL" HARDNESS TESTERS • WORLD'S STANDARD OF ACCURACY



WILSON Offers You the Most Complete Hardness Testing Service

The Widest Choice of Precision Instruments to meet every hardness testing requirement...*A Complete Line of Accessories*...*A Nation-Wide Staff of* WILSON *Hardness Testing Experts* to serve and help you...*The Most Complete, Helpful and Authoritative Literature* on every phase of hardness testing.

WILSON "ROCKWELL" hardness testers are:

Sensitive and Accurate as a precision balance.

Durable as a machine tool — maintaining their accuracy throughout years of operation

Easy to operate — all controls conveniently grouped at your hand

Easy to maintain, with interchangeable mechanisms

The full WILSON "ROCKWELL" line provides many models for Regular, Superficial and Special hardness testing. Semi-Automatic (manual feed) and Fully-Automatic models automatically classify tested pieces as Correct, Too Hard, Too Soft...at test rates up to 1000 pieces per hour.

WILSON TUKON Micro & Macro Hardness Testers provide accurate hardness tests of fine or small precision parts, either metallic or non-metallic.

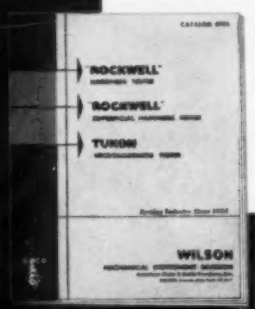
We will gladly send this 44-page Catalog RT55 on request without obligation. It fully describes the many WILSON "ROCKWELL" and WILSON TUKON hardness testing models... the complete line of accessories...and tested techniques for fast, accurate hardness testing.

Other booklets listed here give complete and helpful data on the indicated WILSON "ROCKWELL" equipment and its proper use.

DH-325 for WILSON "ROCKWELL" Regular models

DH-326 for WILSON "ROCKWELL" Superficial

DH-327 for WILSON "ROCKWELL" Accessories and Special models



WILSON "ROCKWELL"
DIAMOND BRALE
PENETRATORS

WILSON TUKON

Micro & Macro hardness testers — for accurate testing of metallic or non-metallic precision parts...such as

fine wire—very thin metal—shallow superficially-hardened surfaces—small components—surface coatings—jewels—plastics—glass—rubber—and many other materials.

WILSON TUKON hardness testers use both Knoop and 136° Diamond Pyramid Indentors.

Typical WILSON TUKON Users

Manufacturers of watches, clocks, precision instruments, cameras, needles, pivots, hairsprings, fine wire, pens, mechanical pencils, precision bearings, small machine components...Producers of coatings, film, electroplating, sheet metal, welds, cemented carbides, ceramics and many other materials...Widely used in laboratory research.

For complete information on WILSON TUKON Micro & Macro Hardness Testers and testing techniques write for this 12-page Booklet **DH-328.** No obligation.

Your hardness testing is no better than the penetrator

The matching accuracy of WILSON Diamond Brale Penetrators and WILSON "ROCKWELL" Hardness Testers, insures perfect hardness testing...*every time.*

This precision combination is your complete assurance of:

Accurate measurements • No rejection of good parts

No keeping of sub-standard parts

No risking of your good name with customers

Every WILSON *Diamond Brale Penetrator provides:*

A flawless diamond—no chips, no cracks

Precise accuracy of penetrator angle

A full appreciation of the essentiality of Penetrator accuracy and uniformity can perhaps be gained from the fact that 0.00008″ (80 millionths) of penetration depth represents 1 point of hardness, using a standard Brale and Regular Rockwell Hardness Tester.

With the Superficial Rockwell Hardness Tester and the N Brale Penetrator, penetration depth of only 0.00004″ (40 millionths) represents 1 point of hardness.

At WILSON, microscopic inspection finds and rejects any diamond with the slightest imperfection...comparator check, with hundreds of magnifications, assures essential accuracy and uniformity of penetrator angle.

ACCO **WILSON**
MECHANICAL INSTRUMENT DIVISION
AMERICAN CHAIN & CABLE
230-F Park Avenue, New York 17, N.Y.

"WEIRZIN® ARRESTS CREEPING CORROSION,"

SAYS CHIEF ENGINEER OF GRAND SHEET METAL PRODUCTS COMPANY, MELROSE PARK, ILL.

"Especially designed to withstand wind, weather, fire and rough handling." That's the manufacturer's description of a Grand Handy House. Metal used? Weirzin.

But listen to what else Grand Sheet Metal Products Company has to say about Weirzin electrolytic zinc-coated steel, as used in their outdoor storage-shelter-utility Handy Houses. From Chief Engineer Edward Rawson:

> "Weirzin material provides a very good surface for maximum paint adherence, which is most important for an outdoor application such as ours.
>
> "High corrosion resistance is also of the utmost importance. Weirzin answers this requirement very well since it arrests any creeping of corrosion where the surface may become scratched or abraded in service. In other words, the corrosion will not tend to spread beyond the damaged area."

What about your products? Have you considered lately how they can be improved economically? Send for free brochure on Weirzin for both outdoor and indoor use. Write Weirton Steel Company, Department S-15, Weirton, West Virginia.

WEIRTON STEEL COMPANY

WEIRTON STEEL COMPANY

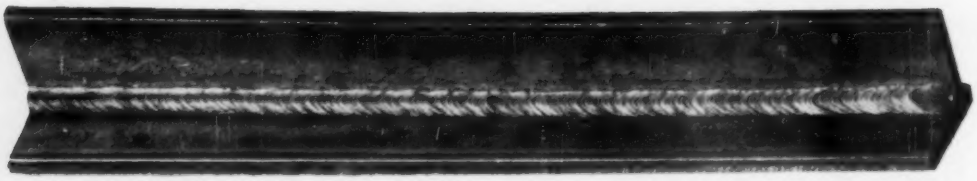
WEIRTON, WEST VIRGINIA

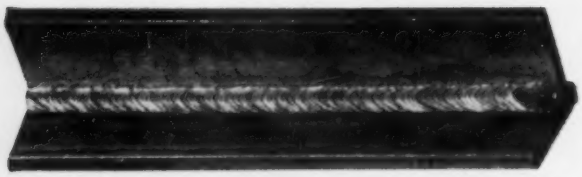
a division of

NATIONAL STEEL CORPORATION

Now . . . another dramatic advance in electrodes

from **AIR REDUCTION . . .**





Over 90% Bonus!

This is the extra weld per rod you get with the new Airco Easyarc Stainless steel electrode

This is what you get with the conventional electrode

A NEW LOW-COST ELECTRODE FOR STAINLESS STEEL

New Airco Easyarc stainless steel electrodes produce over 90% more weld per rod . . . actually cost 29% less per pound than conventional stainless steel electrodes!

The new Airco Easyarc stainless steel electrodes are the first powdered-metal electrodes for stainless steel ever offered! They make possible *tremendous savings,* opening up possibilities for stainless use in many *new applications.*

You can weld practically *any* type of stainless steel with the new series. They are available as Easyarc 308, 316, or 347, the designations being equivalent to the type of stainless they weld. Restriking is instantaneous. Available in sizes from 3/32" to 3/16".

Order the new Easyarc stainless steel electrodes from your nearest Authorized Airco Dealer. Look for his name in the classified section of the telephone book under "Welding equipment and supplies." Or call your nearest Airco office.

welding
AT THE FRONTIERS OF PROGRESS YOU'LL FIND . . .

AIRCO

Offices and dealers in most principal cities

AIR REDUCTION SALES COMPANY

A division of Air Reduction Company, Incorporated
150 East 42nd Street, New York 17, N. Y.

SEE IT AT THE WELDING SHOW

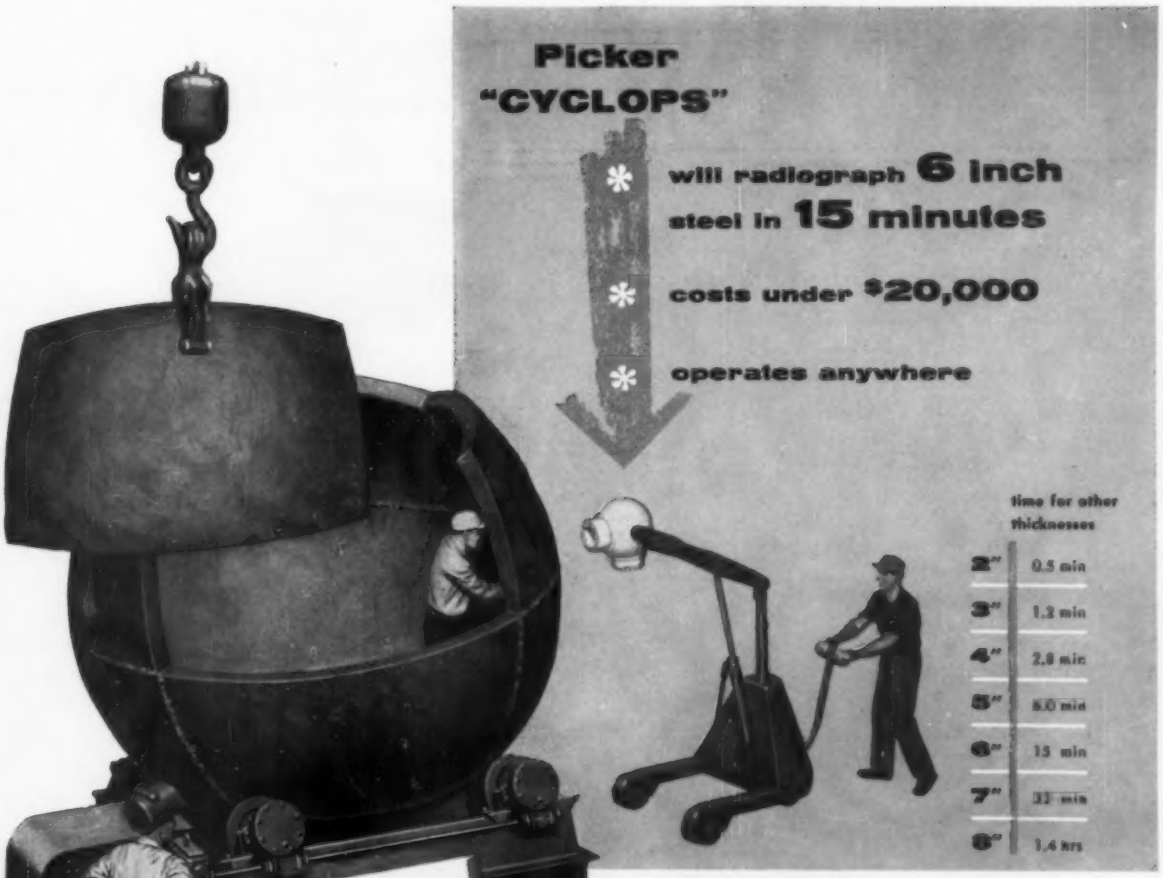
On the west coast —
Air Reduction Pacific Company

Internationally —
Airco Company International

In Cuba —
Cuban Air Products Corporation

In Canada —
Air Reduction Canada Limited

Products of the divisions of Air Reduction Company, Incorporated, include: **AIRCO** – industrial gases, welding and cutting equipment, and acetylenic chemicals • **PURECO** – carbon dioxide – gaseous, liquid, solid ("DRY-ICE") • **OHIO** – medical gases and hospital equipment • **NATIONAL CARBIDE** – pipeline acetylene and calcium carbide • **COLTON** – polyvinyl acetate, alcohols, and other synthetic resins.



quick rundown on CYCLOPS

excellent detail sensitivity
1% and 2% radiographic sensitivity is routine

high energy
Cyclops holds a 1000 rhm source of Cobalt 60; its radiation is equivalent to 2-3 million volt x-rays

low first cost
Capital investment is under $20,000—less than one-quarter the cost of an equivalent supervoltage x-ray installation

low operating cost
No electronic or x-ray tubes; virtually no maintenance

self-contained mobility
Travels anywhere . . . easy to use even in the open at a construction site

completely safe
Engineered for safe operation under all conditions

Wheel "Cyclops" into action like this—then walk away. Start exposure electrically from a remote, fully protected position. *Come back in fifteen minutes and find the job done.*

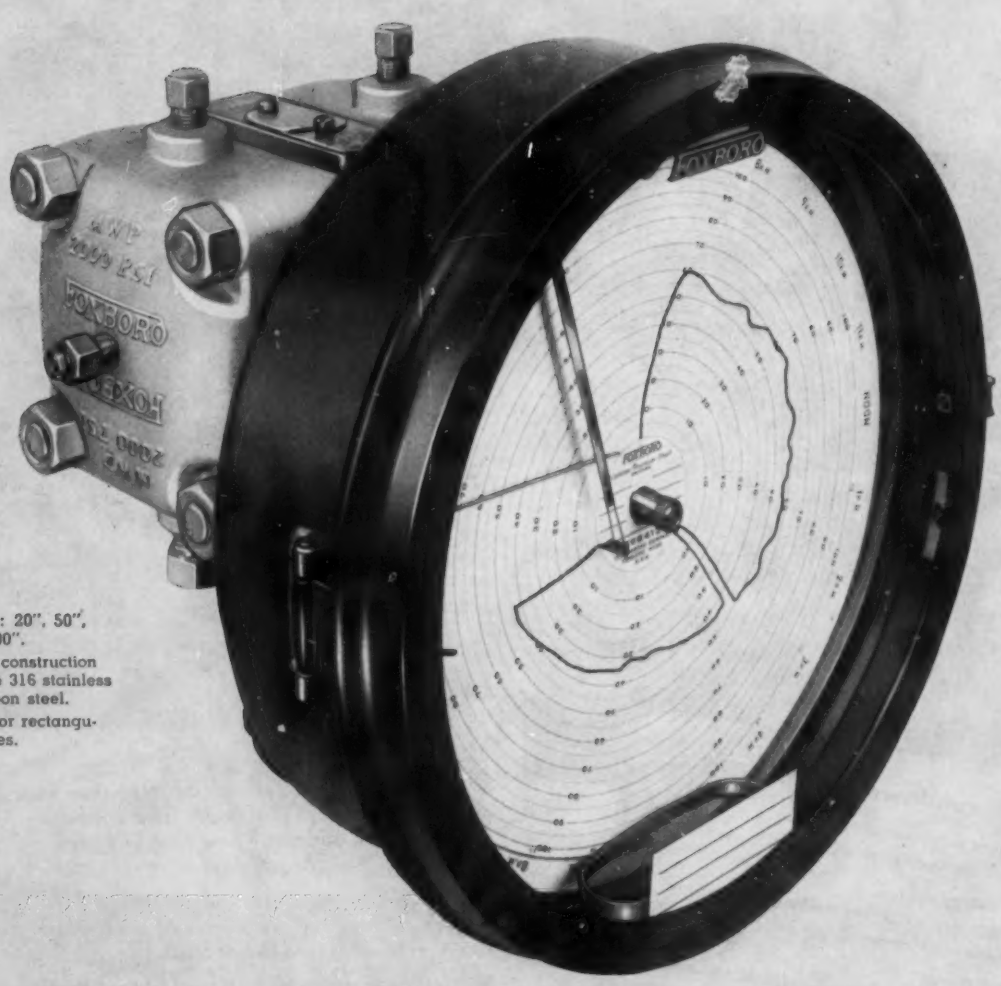
Cyclops is a "natural" for radiographing massive castings and weldments of steel, dense alloys, even solid lead inches thick.

Whatever the nature of your need for radiographic or fluoroscopic inspection, we probably have just the machine to do the job for you. The Picker spread of equipment spans the range from 10 KV x-rays (for paper-thin materials) to 2-3 MEV equivalent Cobalt 60 units.

For information and advice concerning any phase of radiation-utilization, contact any Picker District office (see local 'phone book). Or write, telephone or wire Picker X-Ray Corporation, 25 South Broadway, White Plains, N. Y.

if it has to do with radiation it has to do with Picker x-ray

NOW... a "Dry" Flow Meter with...

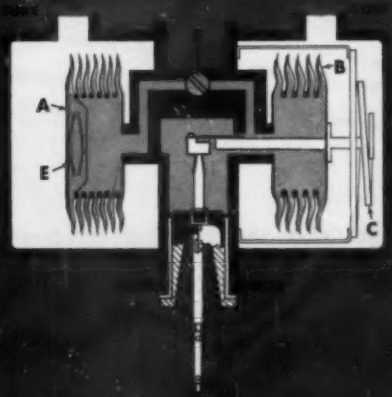


- Ranges: 20", 50", 100", 200".
- Forged construction in Type 316 stainless or carbon steel.
- Round or rectangular cases.

..the new Foxboro Type 37 Diaphragm Meter

How It Works

In schematic drawing at right, areas shown in color represent a stable, non-freezing liquid. Any pressure increase in the high pressure chamber compresses Diaphragm Unit A, displacing its liquid and expanding Diaphragm Unit B until force of Range Spring C equals the difference between the forces on Diaphragm Units A and B. Linear motion of Diaphragm Unit B moves inner end of Drive Bar D — outer end moves correspondingly through the bellows-sealed flexure bar, driving pen arm. Built-in Temperature Compensator (E) proportionately adjusts diaphragm capacity as ambient temperature variations affect volume of filling fluid. External damping adjustment is shown at F.



• *complete overrange protection!*

• *sustained high accuracy!*

Now you can have mercuryless flow measurement for a wide range of differential pressures — at static pressures up to 2000 psi — with greater safety and dependability than ever before!

The new Foxboro Type 37 Diaphragm Meter not only combines unmatched ruggedness and precision in a dry meter — it's by far the easiest to adjust and maintain. And it does away with zero drift problems, once and for all!

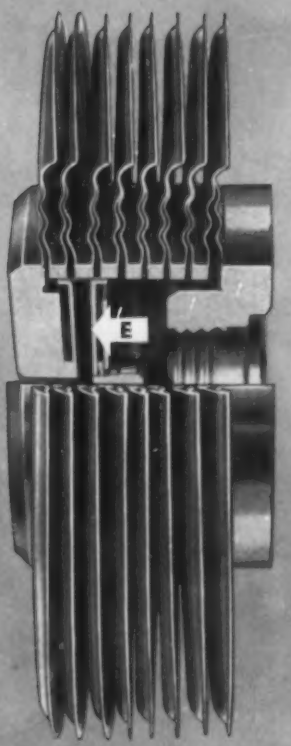
Expansible, Type 316 S.S. diaphragm elements respond to changes in pressure with unmatched sensitivity, yet are completely immune to overrange up to full static pressure! A unique packless drive bar precisely transmits linear motion to the pen arm. Range-changing is easy, due to new twin-spiral spring design. Wide range damping is externally adjustable under pressure. And the Type 37 is self-compensating for temperature changes in all differential ranges.

Get full details on this high utility, completely dependable dry flow meter. Arrange for a demonstration with your nearby Foxboro Field Engineer, or write **The Foxboro Company, 524 Neponset Ave., Foxboro, Mass., U.S.A.**

FOXBORO

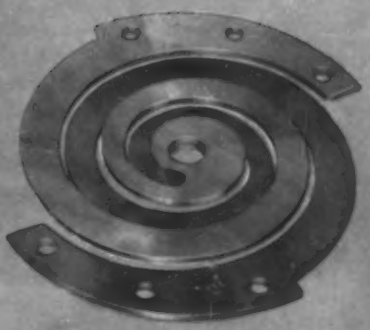
REG. U.S. PAT. OFF.

FIRST IN FLOW METERING



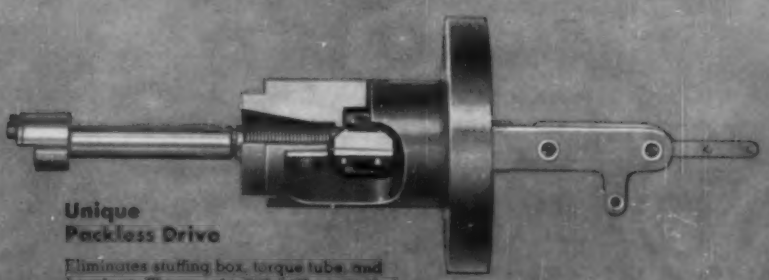
Exclusive Diaphragm Elements

Type 316 S.S. diaphragm units in both high and low pressure chambers provide greatest linearity and freedom from hysteresis; nesting design and integral spacer rings provide safe, positive, overrange protection. Temperature compensation (E) is built into diaphragm assembly . . . never requires change or adjustment.



Exclusive Range Springs

Heavy gauge Ni-Span C alloy, twin-spiral springs provide high sensitivity with lasting accuracy. Readily accessible . . . range changes are easily made, in minutes!



Unique Packless Drive

Eliminates stuffing box, torque tube, and bearings. Flexure-pivoted, bellows-sealed drive bar transmits diaphragm's linear motion to the pen arm with unequalled sensitivity and undiminished power. Seal for flexure pivot is a tough, flexible bellows.

1948 — ORGANIZATION OF BETTIS ATOMIC POWER DIVISION

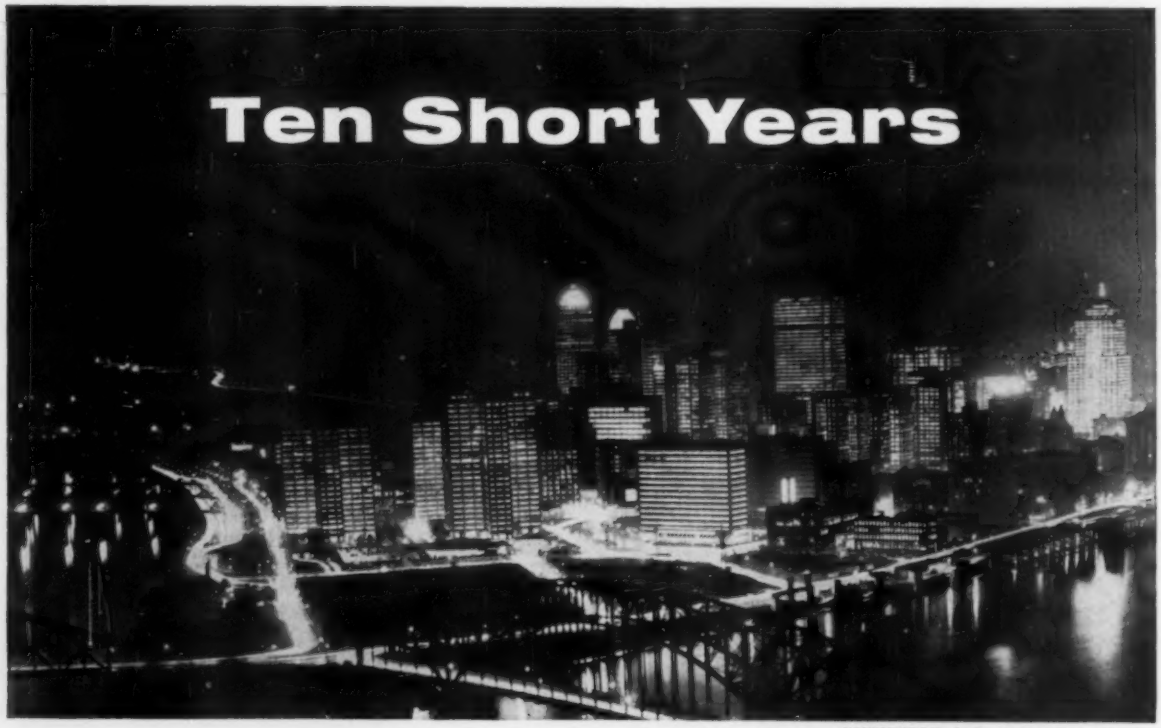
1953 — DEVELOPED: FIRST NUCLEAR PROPULSION UNIT

1955 — BUILT: REACTOR FOR FIRST NUCLEAR SUBMARINE

1957 — COMPLETED: FIRST FULL SCALE COMMERCIAL NUCLEAR POWER PLANT

TODAY—"AS WE LOOK TO THE FUTURE OF NUCLEAR POWER IT IS EVIDENT THAT WE ARE STILL FAR FROM OUR ULTIMATE GOAL OF TOTAL DEVELOPMENT . . . AND WITH EACH NEW DISCOVERY OUR AREA OF INVESTIGATION BROADENS, THE JOB TO BE DONE GROWS LARGER."

Ten Short Years



PITTSBURGH, the Renaissance City of America

"The past ten years have shown a tremendous advance in nuclear technology, yet every step forward reveals a still broader view of the future and one realizes that the next ten years will show an even greater acceleration in the development of this new power source. In short, to date we have done little more than make a good beginning.

The young men who enter this field today will have the responsibility of creating a solid structure of knowledge and accomplishment from this beginning. Yet, even they, ten years from now, will look ahead and know they are still far from fully realizing the ultimate potential of nuclear energy."

You can participate in the continuing development of this expanding field of activity. A field whose only limits are the creativity of man's mind and the extent of his desire to learn. If you are a U. S. Citizen with an advanced degree in Physics, Mathematics, Metallurgy, or Engineering, and would like to apply your knowledge to the field of nuclear power, send your resume to: Mr. M. J. Downey, Dept. #A-42, Bettis Atomic Power Division, Westinghouse Electric Corp., P.O. Box 1468, Pittsburgh 30, Pa.

BETTIS ATOMIC POWER DIVISION

Westinghouse

BETTER YOUR FUTURE AT BETTIS

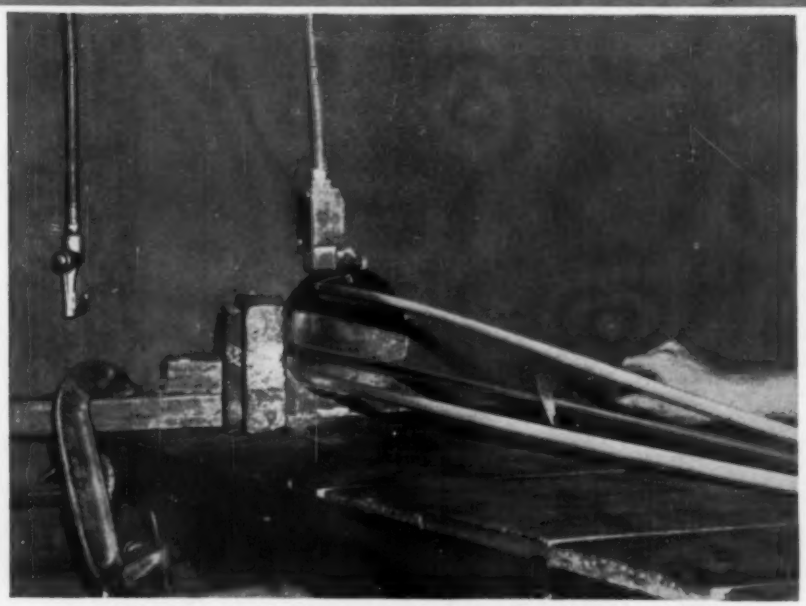
Tool Steel Topics

BETHLEHEM STEEL

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation



Showing extrusions leaving the press. The die of Cromo-WV tool steel is not visible.

Die made from Cromo-WV passes tough extrusion test

Quality plus economy — that's the kind of a die steel they needed at American Aluminum Extruders, Miami, Fla., to produce aluminum extrusions used as decorative trim. Our local tool steel distributor, J. M. Tull Metal & Supply Co., Inc., recommended Bethlehem Cromo-WV.

"We've had a lot of experience with this grade," they said. "Give it a try, and the performance figures will speak for themselves."

That's just the way it turned out. Cromo-WV was satisfactory in every way. Hardened to Rockwell C-47, the die extruded about 2,500 lb of aluminum before polishing was required.

Cromo-WV, in addition to its 5 pct chrome, contains .30 pct vanadium. It is a modification of our popular Cromo-W, the original 5 pct chrome hot-work steel. Like Cromo-W, it combines red hardness, shock resistance, and resistance to heat-checking. It is an ideal grade for extrusion work.

Your Bethlehem tool steel distributor will be pleased to supply Cromo-WV, whether you want a production quantity or just enough to give it a trial.

IT'S TOPS FOR BOTTLE CAPS

Here's a die made of BTR (Bethlehem Tool Room) which was used in producing millions of tinplate bottle caps. The die was hardened to Rockwell C-61, and was redressed about every third month. BTR is our general-purpose manganese-chromium-tungsten grade of oil-hardening tool steel. Tough, and safe-hardening, you can count on it for extremely long wear.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

In Machining Operations, Chips Tell a Story

A good way to evaluate a machining operation is to examine the chips carefully. This step is particularly valuable in operations where large amounts of metal are removed at high speed.

Generally, the color and shape of the chips tell a story which, when properly interpreted, can lead to improvements in the operation. For example, when machining with high-speed steel tools, the chips produced should show some temper color (yellow or brown). If they do not, it means that speed and feed might be increased greatly, boosting the production rate on the machine. When machining with carbide or ceramic tools, the chips should always be highly temper-colored (purple or blue). If otherwise, you are probably "under-machining."

The shape of the chips will vary with the type of steel being machined, but comparison of chip shape under varying conditions may provide valuable information. The ideal chip shape, indicating ideal machining conditions, is like the letter "C." Often the "C" can have a decided flourish, but this form of chip (on steel) is best. Generally, the secret of producing "C" chips lies in the proper balance of feed and depth of cut, versus speed. These factors should be varied whenever other types of chips are produced, to develop the best machining conditions.

Examination of chip shape is also of value for control purposes. For example, if "C" chips are being produced in a machining operation, and they become gradually longer or stringy, it indicates the tool is becoming dull, and requires resharpening.

It is difficult to establish more specific rules which apply to all machining operations, due to their variety and complexity. However, you can be sure that the proper control of chip color and shape will pay off in increased production.

precise heat for precision casting

You'd *expect* the accurate heat of an induction furnace to be an important consideration in permanent mold, shell mold, and investment casting . . . and it *is!* But in addition to precise temperature control, Ajax-Northrup high frequency induction furnaces provide the precision foundry with *flexibility*, *purity*, and *economy*. That's why Ajax leadership in melting for precision casting has never been challenged.

One furnace—hundreds of alloys: Ajax-Northrup furnaces can handle any one or all of the hundreds of ferrous and non-ferrous alloys being made today. For many alloys, it's the only furnace that *can* be used. Magnet alloys, for example, depend on the inherent stirring action which assures ideal dispersion of all elements throughout a melt . . . and the most uniform possible cast part analysis.

Pure metal protects part quality: There's no flame, no smoke, no physical contact between coil and metal. Melts are always 100% on analysis, because there's no chance of contamination . . . particularly important when you're dealing with the finicky alloys common in precision casting.

A better melt at a lower cost per melt: Because every melt is uniform and to exact composition, bad melts become a thing of the past. Subsequent machining is minimized. Ajax-Northrup's unique control system assures maximum melting efficiency—lower melting costs. And new, compact designs minimize floor space requirements, installation costs and maintenance.

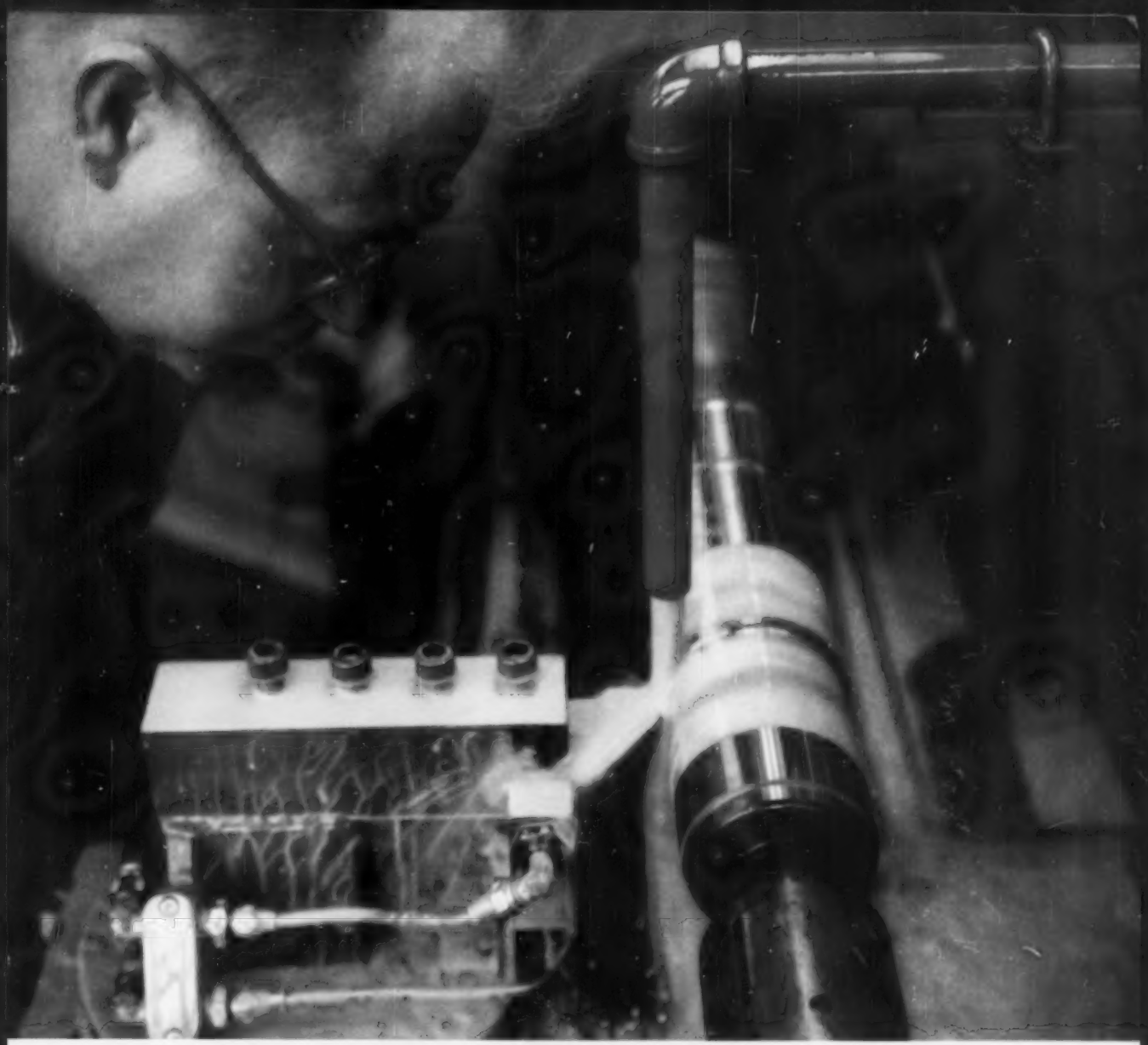
Induction heating & melting

AJAX

NORTHRUP

Available in every conceivable capacity from a few ounces to several tons . . . powered by massive motor-generator sets or economical converters . . . there's an Ajax-Northrup induction furnace sure to satisfy your needs perfectly. We'll gladly send you further information or, if you wish, arrange a meeting with qualified furnace engineers to discuss your special requirements. Ajax Electrothermic Corporation, Ajax Park, Trenton 5, New Jersey.

ASSOCIATED COMPANIES: AJAX ELECTRIC COMPANY-AJAX ENGINEERING CORPORATION



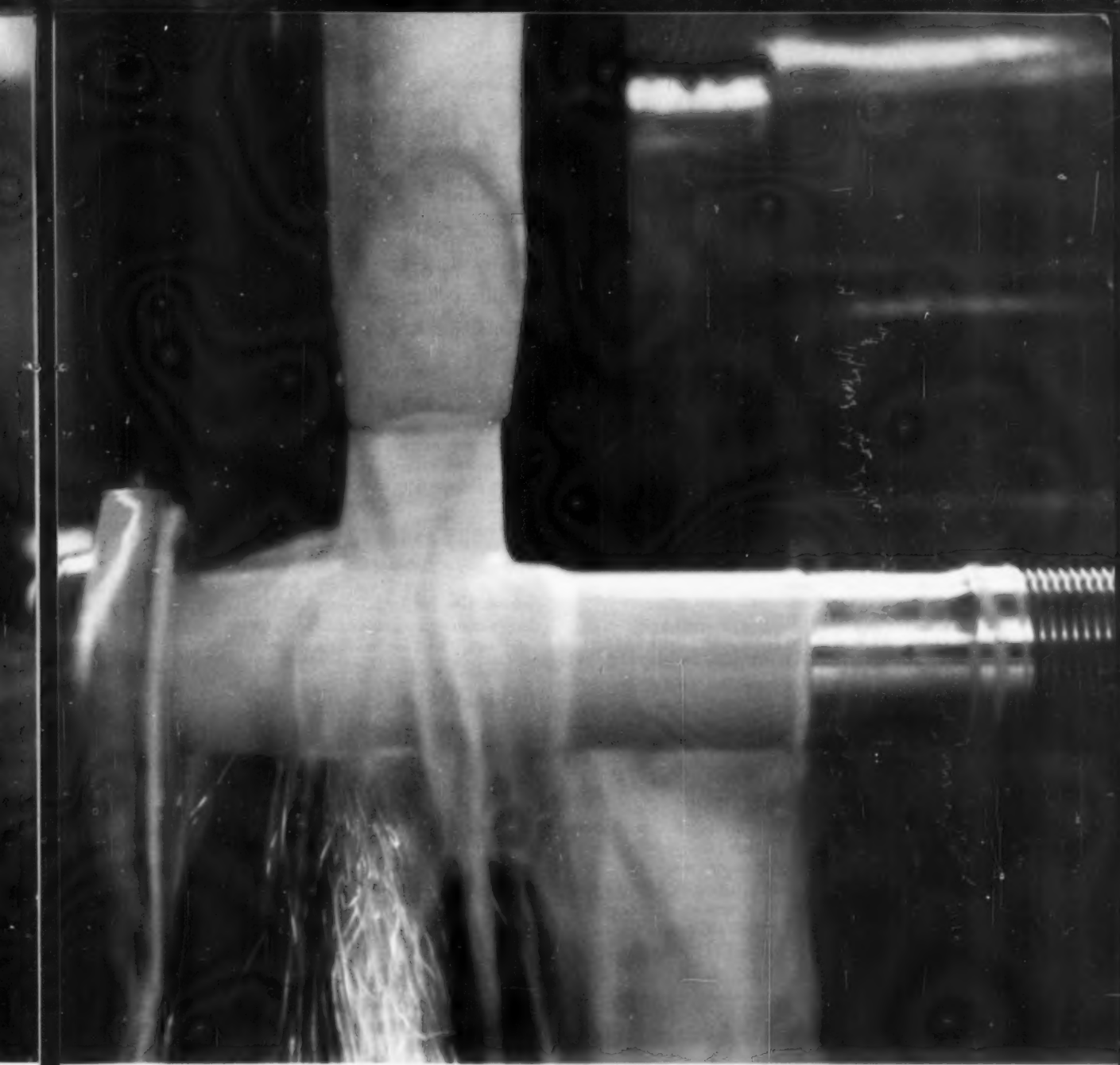
Lehmann 18" Hydratrol lathe turning 4" Nitralloy 135 modified bar stock. Tool is K7H carbide nitriding steel. Feed .011", depth of cut .100", speed 300 sfm. Coolant is 20% emulsion of Gulfcut Heavy Duty Soluble Oil.

You can make heavier cuts... at higher speeds...with new GULFCUT HEAVY DUTY SOLUBLE OIL

Norton Type C Cylindrical Grinder grinding SAE 4140 steel connecting rod bolts to 4 micro-inch finish. Speed is 225 sfm, depth of cut .020" with 30" x 1" aluminum oxide wheel. Emulsion concentration 32:1 Gulfcut Heavy Duty Soluble Oil.

This aluminum connecting rod and piston assembly was turned at 4000 sfm to a 6-micron rms finish with Gulfcut Heavy Duty Soluble Oil.

You'll get finer finishes, too, when you use new GULFCUT HEAVY DUTY SOLUBLE OIL



For threading, boring, facing, turning, grooving, grinding, or any operation that requires an emulsifying oil, you'll get better results with new Gulfcut Heavy Duty Soluble Oil. On tough jobs where other general purpose oils have failed, Gulfcut Heavy Duty Soluble meets all requirements—even on low machinability metals.

This new oil is economical, too. An average mixture of 1 part to 25 parts of water provides good cooling and superior lubrication. In many field tests, it has performed well even in mixtures of 1 to 150!

Gulfcut Heavy Duty Soluble Oil won't separate or gum in wheels, slides, ways or other machine parts. It provides greater protection against rust . . . has excellent emulsion stability, even in hardest water . . . has high surface-wetting properties for more effective cooling . . . and contains powerful anti-foam and anti-weld agents. In addition, it contains an effective germicide to help eliminate rancidity.

To improve your production and cut your machining costs, try new Gulfcut Heavy Duty Soluble Oil. For more information, just call a Gulf Sales Engineer at your nearest Gulf office. Or use the coupon on the next page to get illustrated booklet.

GULF

In the complete Gulfcut line, there's a cutting oil to meet your every need

By ordering "Gulfcut" you can select from many different shop-tested cutting oils, including mineral-lard oil, sulfurized-mineral oils, sulfurized-mineral-lard oils, sulfo-chlorinated-lard oils, and emulsifying oils. Your Gulf Sales Engineer will gladly advise you.

GULFCUT 11A AND 11D

Non-staining, non-corrosive mineral-lard oils, recommended for machining non-ferrous metals.

GULFCUT 21A, 21B AND 21C

Sulfurized-mineral oils made by a special Gulf process to provide greater sulfur activity over a wide range of machining operations. They are transparent and relatively light in color.

GULFCUT 31A AND 31C

Sulfurized-mineral-lard oils that excel over a wide range of machining operations on many types of steel. Have outstanding anti-weld properties and load carrying ability. Sulfur is combined in three different forms for maximum chemical activity.

GULFCUT 43A

Sulfo-chlorinated oil for high production machines requiring an oil of this type for pipe cutting and threading, screw and bolt making machines, and cutting operations on steels with free and moderate machinability characteristics. Contains a corrosion inhibitor to protect ferrous metals and machine parts.

GULFCUT 43B

Specially blended sulfo-chlorinated-lard oil for high production machines requiring an oil of its viscosity and compounding. Dual purpose—suitable for machine lubrication as well as for cutting operations.

GULFCUT 45A AND 45B

High quality sulfo-chlorinated-lard oils with excellent load carrying and anti-weld characteristics to insure best results on the most difficult jobs. Have heavy concentrations of sulfur, chlorine and fatty oil. May be diluted for less difficult jobs.

GULFCUT 41A, 41B AND 41C

Sulfo-chlorinated-lard oils for high production jobs on automatic machines. Engineered with the proper combination of sulfur, chlorine and fatty oil. They also provide proper lubrication for machine tools.

GULFCUT 41TG

This is a sulfo-chlorinated-lard oil specifically compounded for thread grinding operations.

GULFCUT SOLUBLE OIL

Emulsifying oil with a wide range of uses in cutting, forming and rolling operations where a coolant with moderate lubricating properties is required. Mixes with warm or cold water as high as 100 to 1. Forms homogeneous and exceptionally stable emulsions.

GULF OIL CORPORATION
Dept. DM, Gulf Building
Pittsburgh 30, Pa.

Yes! Send me illustrated bulletin on

☐ Gulfcut Heavy Duty Soluble Oil
☐ Gulfcut "Regular" Cutting Oils

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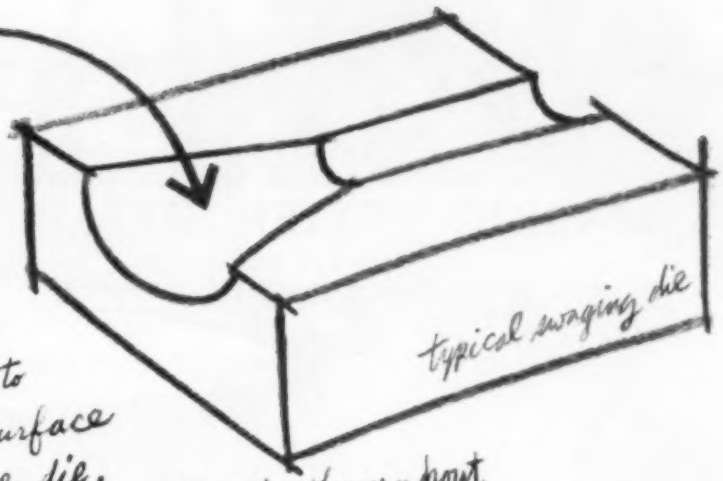
FOR ALL YOUR NEEDS



Strength and toughness at core are vital. Poor quality leaves only weak core metal to take stress, because better surface metal is cut away to shape die. Mel-Trol alloys provide more uniform strength throughout, help solve problems of broken dies, too-rapid wear resulting from poor centerline quality often found in ordinary steels.

MEL-TROL®

...produces the first alloys with really predictable performance right through the core

Until now, it's never been possible to look at an alloy bar and be sure its center is sound and tough. Sometimes centerline weakness won't show even in a cross section. But it *will* show in rejects, breakage, rapid wear. The swaging die illustrated is just one example.

Carpenter Mel-Trol alloys are the answer to problems involving core quality. They provide greater freedom from segregation, porosity and center separation. Carpenter's exclusive Mel-Trol process is the reason.

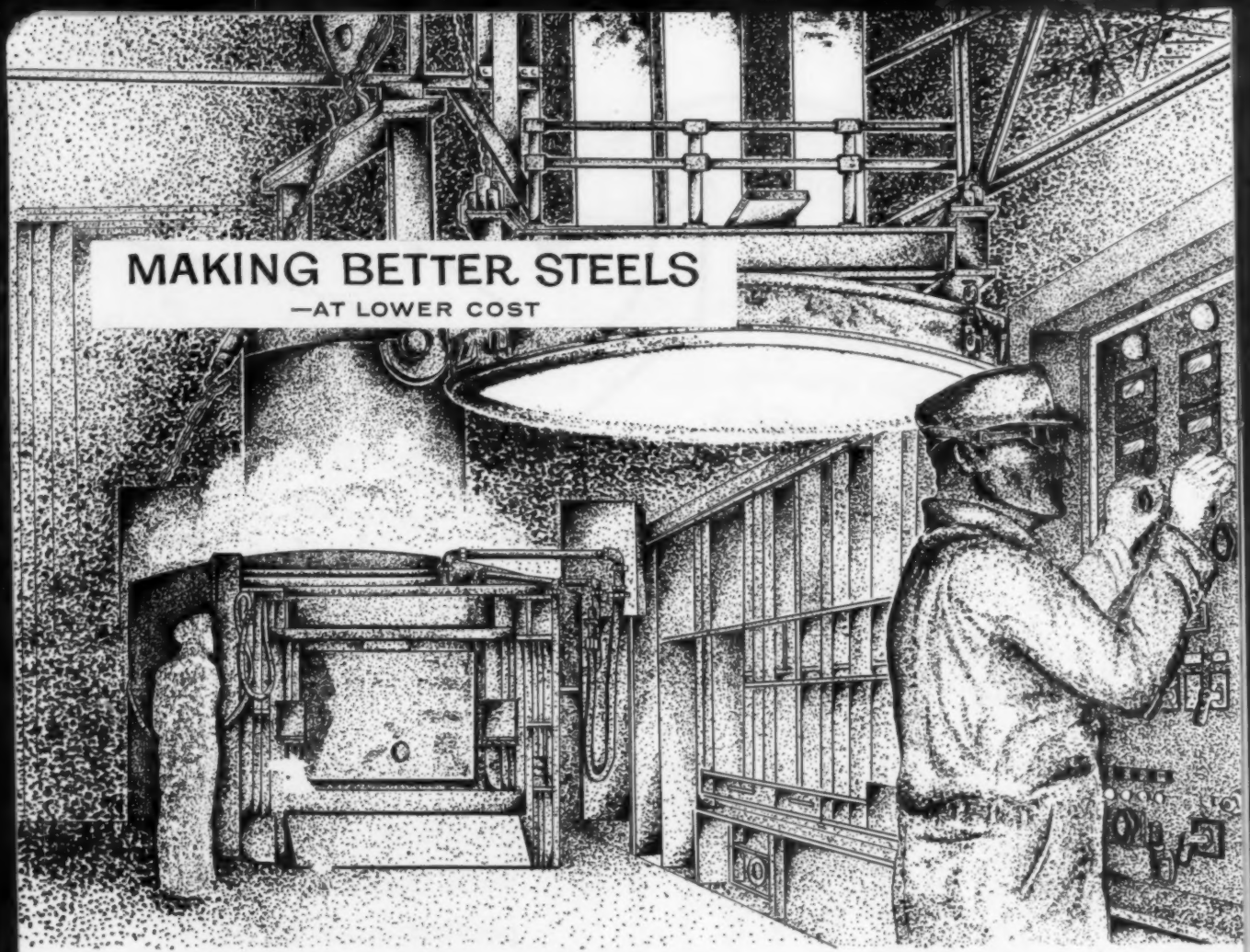
Mel-Trol is an integrated system of quality controls using patented Carpenter-developed equipment supplemented by the most modern equipment and methods commercially available. Mel-Trol is a part of the steelmaking process from scrap selection through final preparation of stock shapes.

There's a Carpenter service representative near you who'll be glad to show you how Mel-Trol alloys are ending reject problems, producing improved tools and parts for many famous metalworking companies. You can do the same. Call him today.

Carpenter STEEL

The Carpenter Steel Company, 133 W. Bern St., Reading, Pa.
Export Dept.: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

Pioneering in improved specialty steels through continuing research



CHARGING

. . . the electric furnace takes a storehouse of know-how—from scrap selection control and accurate weighing and loading procedures to a sixth sense that says, "That's it".

Experienced melters also find that a **GLC graphite electrode column with the "weld-strength" Unitrode® nipple** helps them make better steels at lower cost.

FREE—*This illustration of one of the skills employed by the men who make the metals has been handsomely reproduced with no advertising text. We will be pleased to send you one of these reproductions with our compliments. Simply write to Dept. P-4.*

ELECTRODE GLC® DIVISION

GREAT LAKES CARBON CORPORATION

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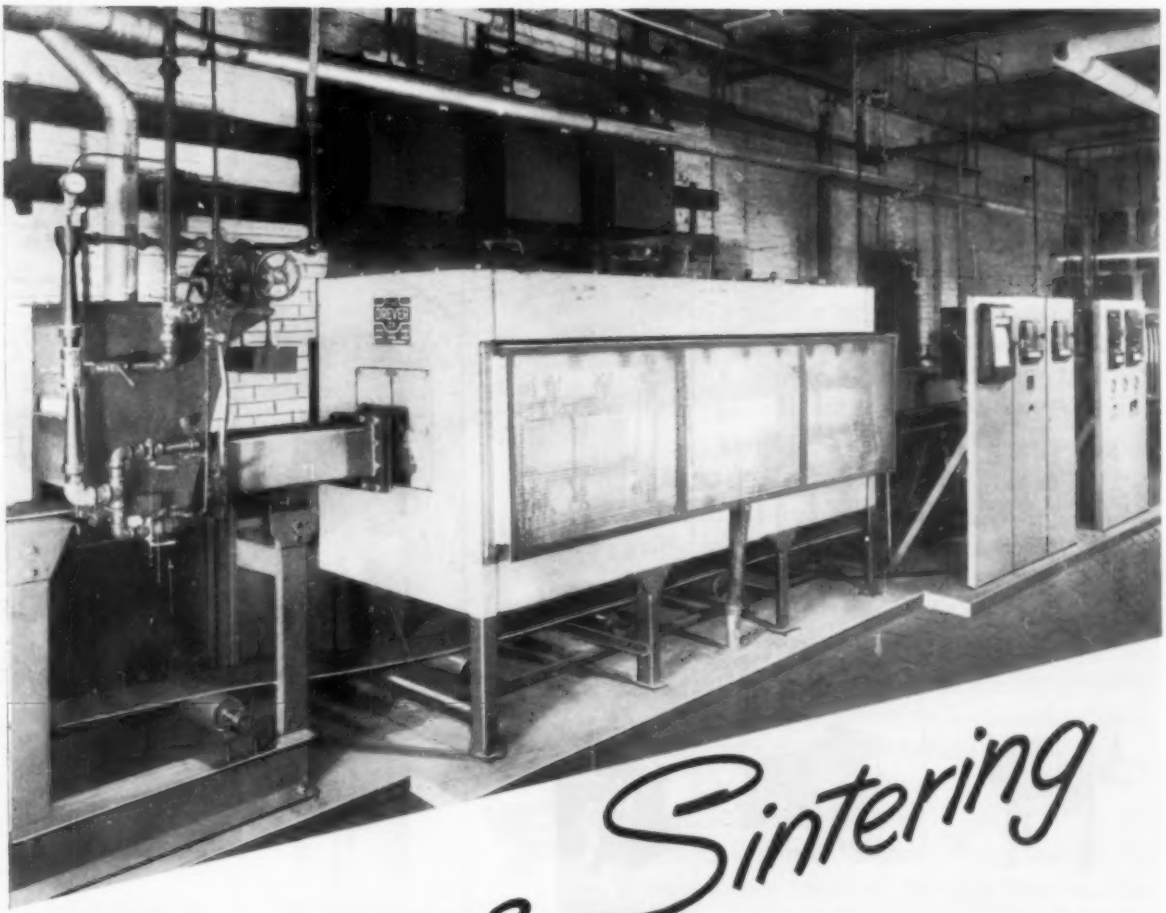


Continuous Sintering of

Brass, Bronze, Iron and Alloy Metal Powder Parts in one furnace

- The versatility of this furnace is of particular interest to the small producer.

Pictured is a 54-KW Belt Conveyor Furnace with Alloy Muffle.

Furnace is suitable for use with Dissociated Ammonia or any other controlled atmosphere.

Maximum operating temperature 2100°F. Complete automatic temperature control.

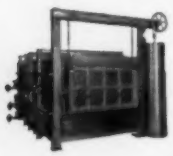
Burn-off Chamber can be added and is recommended for sintering brass.

Production 100 to 150 lbs/hour.

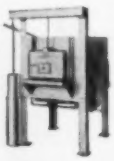
DREVER COMPANY

RED LION RD. AND PHILMONT AVE.
BETHAYRES, PA.

SURFA



large oven



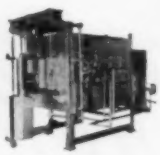
small oven

laboratory

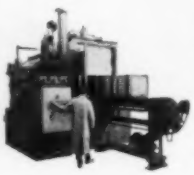
circular pot

rectangular pot

forge



balco® atmosphere



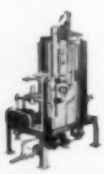
allcase® atmosphere

horizontal muffle

vertical muffle

brazing

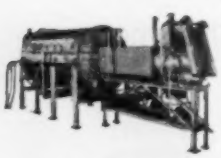
sintering



MRX® atmosphere generator

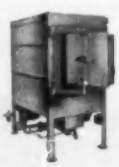
MDX® atmosphere generator

MAX® atmosphere generator

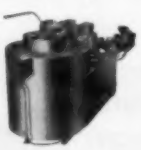


stainless steel

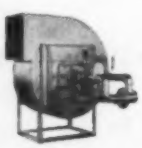
rivet heater



horizontal convection



vertical convection



direct air heaters

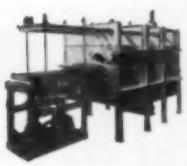
C E

tilting metal melting

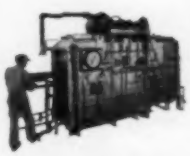
stationary metal melting

soft metal melting

aluminum melting-holding

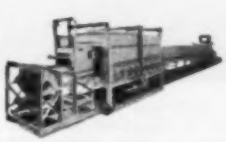


continuous snap hearth



continuous link belt

indirect air heaters



continuous brazing

widest selection

The Surface line of Standard Rated equipment offers a broad range of types and sizes to choose from. Exactly what is needed can be selected. Standard furnaces can be modified to meet the demands of unusual applications.

known production rates

Rated production makes it easy to determine the quantity of finished product which a Surface unit will produce in any given period of time.

known operating costs

Tabulated figures and performance curves on all units clearly indicate in advance the operating cost per pound of finished product.

quick delivery

Surface standardization permits stocking the same parts for many different furnaces. This cuts engineering and procurement time. Surface also offers 80 types and 800 sizes of industrial burners—the same as used on Standard Rated furnaces—for application to your existing furnaces or other requirements.

Write for Bulletin SC-175.

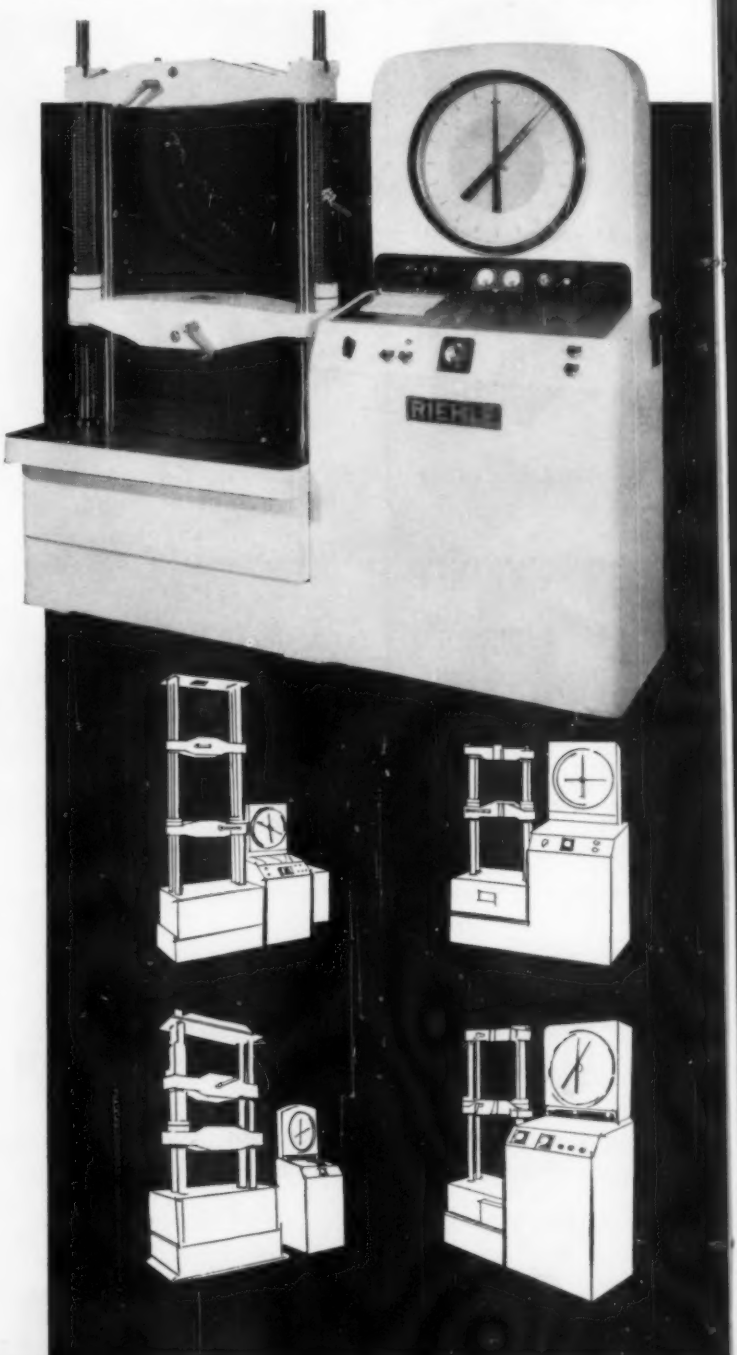
wherever heat is used in industry

Surface

Surface Combustion Corporation
2377 Dorr Street, Toledo 1, Ohio. In Canada: Surface Industrial Furnaces, Ltd., Toronto, Ont.

These universal testing machines

FACILITATE ALL MODERN RESEARCH AND CONTROL PRACTICES



Today's stringent testing requirements and demanding test schedules call for a universal testing machine with both the high sensitivity and rapid response of a Riehle. In addition, progress in modern practices of research and production control demand the broad flexibility that a Riehle provides.

For example, equipment and instruments now available bring programmed tests for both creep and relaxation and under vacuum furnace conditions into the scope of this machine's functions.

Hydraulic and screw power testing machines are available in capacities from 2,000 lbs. to 450,000 lbs. as standard. Riehle welcomes special application problems for testing equipment.

OTHER RIEHLE TESTING MACHINES: Creep and Stress-Rupture Testing Machines, Hydraulic Fatigue Testing Machines, Construction Materials, Impact, Brinell, Torsion, Horizontal Chain, Rope and Cable Testers, Portable Hardness Testers for Rockwell Readings, Etc.

Riehle TESTING MACHINES

A DIVISION OF

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APPLICATION and EQUIPMENT

Holding Furnace

Stroman Furnace and Engineering Co. has announced electric resistance holding furnaces for all aluminum die casting, permanent molding and similar automated processes. They are made in four holding capacities, from

500 to 2000 lb. of aluminum. They are small which makes it possible to position them close to the casting machine or, in some cases, under it. The resistance elements are located in a removable roof.

For further information circle No. 714 on literature request card, page 48-B.

Hardness Tester

A three-in-one portable Rockwell-type hardness tester has been announced by G. A. Peabody Industrial Co. It is entirely mechanical and records direct hardness values equivalent to Rockwell A, B, and C laboratory bench-type machines. The instrument weighs less than 3 lb. and has a diamond penetration depth of less than 0.005 in. High finished and polished surfaces, rounds of 1/16 in. in diameter, sheet steel in coils or bundles and irregular sizes and shapes may be tested.

For further information circle No. 715 on literature request card, page 48-B.

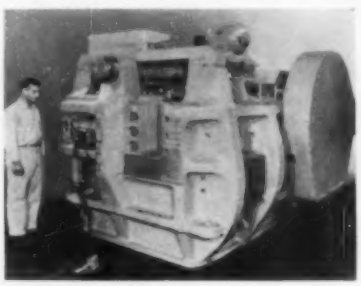
High-Temperature Cements

Morganite, Inc., has announced high-temperature cements for securing wire and foil strain gages to components prior to high-temperature tests. The cements are suited to heat resistant steels and Nimonic alloys and when applied to these materials have an operating range up to about 1400° F. The bond is not as effective on nonferrous materials as on steel. Brimor U527 is a medium hardness cement used where strains in the test component are large and associated with high-frequency vibration. Brimor U529 has a high bond strength when finally cured and should be used when a high degree of cement-metal adhesion is required.

For further information circle No. 716 on literature request card, page 48-B.

Forging

New feed mechanisms which transfer the blanks automatically from the loading chute and through the forging operations have been announced by Ajax Mfg. Co. One system feeds



various lengths of blanks ranging from 8 to 30 in. into the machine. The blank is heated only on the end to be upset, and is lowered through the die operations in the throat of the machine by means of air actuated grips. The blank is rotated between operations to assure uniform heading. The second system is based on a series of cams which actuate mechanical grips and lower the stock through each forging operation. The forging machine pictured was automated to forge stem pinions from 1 9/16 in. diameter stock, 15⅛ in. long and weighing 8¼ lb. A forging is produced with every revolution of the machine and ejected automatically into a lower chute.

For further information circle No. 717 on literature request card, page 48-B.

Ultrasonic Cleaner

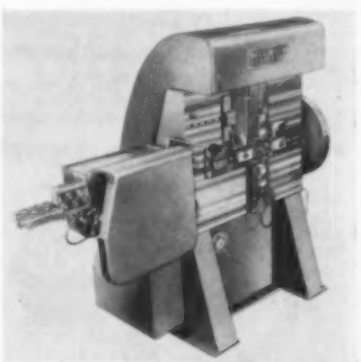
A new ultrasonic cleaner for small parts and assemblies has been announced by Lawrence Mfg. Co. Made

of stainless steel and weighing 53 lb., the unit can accommodate parts up to 10 in. in length. One-dial tuning and compact design are featured. One or two ultrasonic chambers may be used concurrently.

For further information circle No. 718 on literature request card, page 48-B.

Forming Machine

The A. H. Nilson Machine Co. has announced a 4-slide forming machine with which forming is done in a vertical rather than a horizontal plane. A drive shaft is located behind the face of the machine. Forming slide rolls are placed in the center of the slides to give a centralized thrust from low-



How the purity of Electromanganese® eliminates steel-making "bargains" that cost money

In theory few metallurgists will argue that pure Electromanganese® makes a better steel additive than manganese alloys that are contaminated with elements detrimental to the finished product.

In practice, however, metallurgists may frequently choose alloys that contain the manganese they want as well as elements they don't want, can't use, and would be better off without! *Their reason*: it's cheaper! *Their problem*: getting rid of the undesirable elements . . . if they can. *The result*: for the most part, adequate but less-than-the-best quality in the finished product.

But let's take a *good* look at the price tag. Are contaminated manganese alloys really cheaper than the pure element? Today's cost difference between other manganese alloys and pure Electromanganese is only a few pennies. This small differential is easily overcome. For example, commercial use of carbon- and silicon-free Electromanganese in low carbon aluminum killed sheet steel shows potential economic and quality advantages in the following areas:

1. Improved furnace and deoxidation practice
2. Improved deep drawing characteristics
3. Improved sheet quality; i.e., fewer surface rejections

R E S U L T : better quality at lower cost for you and your customers.

When you buy Electromanganese—Foote's electrolytic manganese, guaranteed 99.9% pure—you improve steel quality, cut down rejects, and end up with real dollars-and-cents savings. A Foote engineering representative is ready to tell you about actual case histories in other plants . . . help you work out what you might expect in your own. Until then, Bulletin 201 will give you more details on Electromanganese, the special Hydrogen-Removed Grade (H:7.5ppm), and Nitrided Grades.

Write Technical Literature Department, Foote Mineral Co., 424 Eighteen West Chelten Building, Philadelphia 44, Pa.

Foote
MINERAL COMPANY

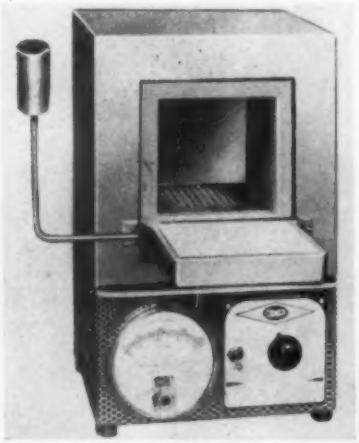
ELECTROLYTIC MANGANESE METAL • NITRELMANG • HYDROGEN-REMOVED ELECTROMANGANESE • RIMEX MANGANESE SULPHIDE • WELDING GRADE FERRO ALLOYS • COMMERCIAL MINERALS AND ORES LITHIUM METAL, CHEMICALS, MINERALS • ZIRCONIUM, TITANIUM, HAFNIUM (IODIDE PROCESS)

angle barrel cams, mounted in the frame. The finished product is ejected to the front. The Vertiform handles both wire and ribbon metal stock.

For further information circle No. 719 on literature request card, page 48-B.

Furnaces

Thermo Electric Mfg. Co. has announced four new, electric bench-type furnaces. They differ in voltage requirements (115 or 230 v.) and in mode of temperature control. They may be used for laboratory testing, process control and small-unit heat

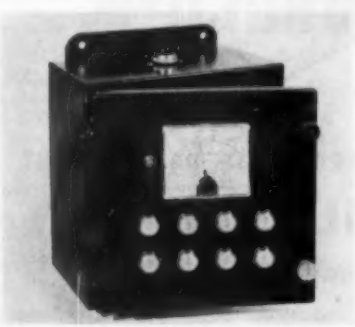


treating. The furnaces consist of two sections. The heating chamber has a 20-gage steel shell with steel backplate. The lower section houses the controls. The heating unit is a refractory plate, in which an element of coiled nickel-chromium wire is embedded.

For further information circle No. 720 on literature request card, page 48-B.

Temperature Scanner

A multipoint temperature scanner which provides over or under-temperature protection for systems where one alarm is to control several points has been announced by Tipptronic, Inc. Thermocouples, which may number from 4 to 56, are connected to a stepping switch, which samples the output of each thermocouple. A signal



is then delivered to the signal terminals of a contact meter. If any of the points scanned should happen to be beyond the set-point, an alarm is sounded, a light corresponding to the offending thermocouple lights and the scanner is stopped at that point.

For further information circle No. 721 on literature request card, page 48-B.

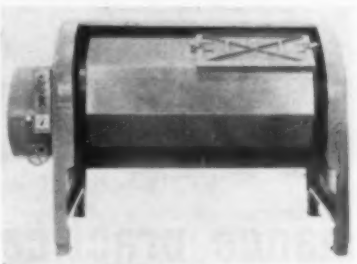
Arc Welding Machine

A new mechanized welding machine for the submerged arc process has been announced by the Lincoln Electric Co. It has automatic wire feed, flux flow and travel speed, but permits manual guiding of the welding arc. Speeds up to 70 in. per min. using up to 600 amp. are possible. The welder can be used on materials over 10-gage thick.

For further information circle No. 722 on literature request card, page 48-B.

Barrel Finishing

Barrel finishing machines with capacities ranging from 5 to 25 cu. ft. have been announced by Crandall Engineering & Manufacturing, Inc. The machines employ a large variable-speed V-belt system instead of chain drives. The cylinder opening and the cylinder door are sealed by vulcanized molding. All models have full open-



ing doors with no ledges to catch media and parts. The motor is standard Nema re-rated 1800 r.p.m. on a fixed mount at the rear of machine. Horsepower used varies with the machine size.

For further information circle No. 723 on literature request card, page 48-B.

Electronic Integrator

A new electronic integrator with a counting rate of 2400, 1200 or 600 counts per minute has been announced by the Wheelco Instruments Div. of Barber-Colman Co. It was developed for use in chromatographic applications to measure the relative quantity of components in gas mixtures. The new integrator has been designed for use with the Wheelco 8000 Series potentiometer-type strip chart recorder. The circuitry used for the electronic integrator incorporates a

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marks like a crayon...
tells temperatures like a precision instrument!

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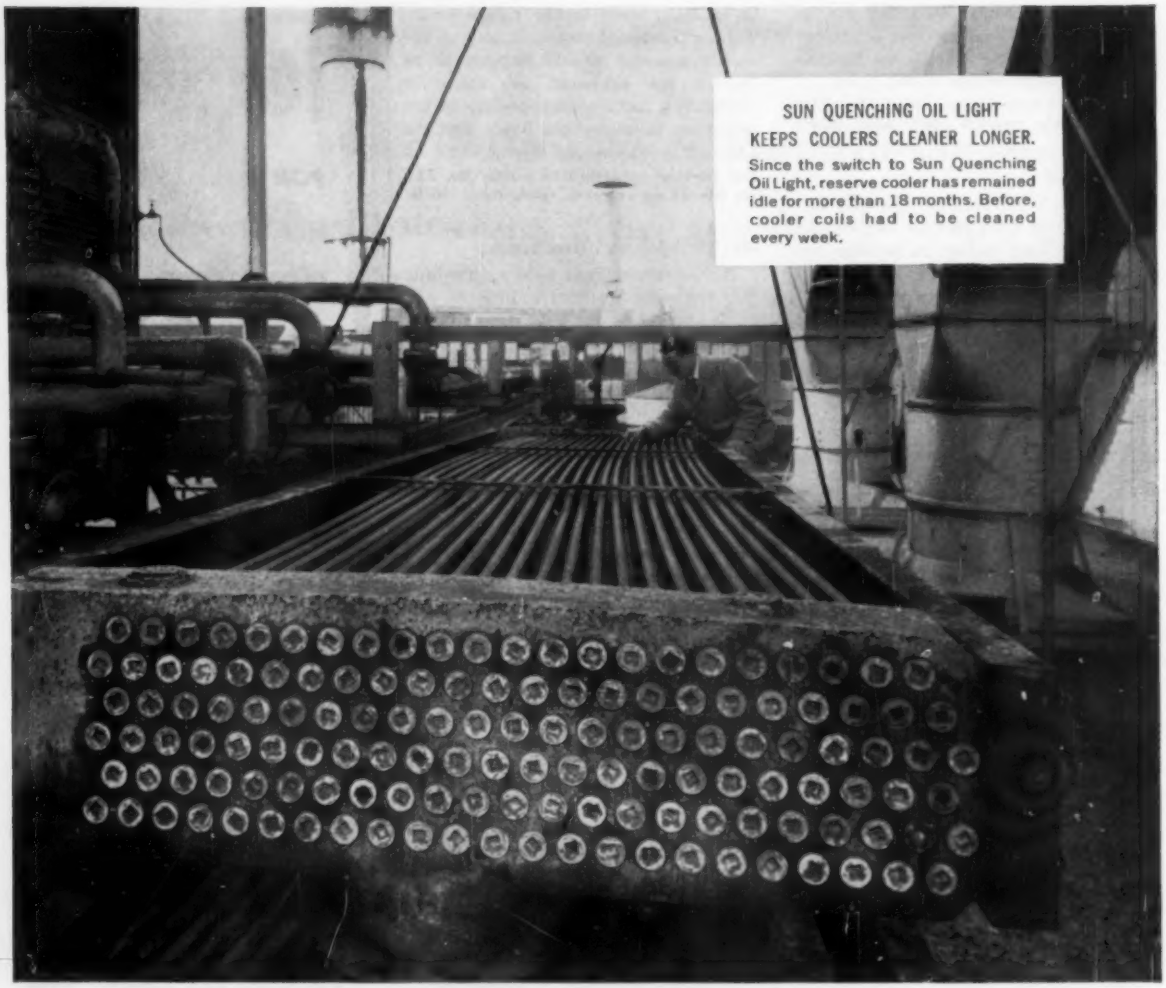
SUN QUENCHING OIL LIGHT
KEEPS COOLERS CLEANER LONGER.
Since the switch to Sun Quenching Oil Light, reserve cooler has remained idle for more than 18 months. Before, cooler coils had to be cleaned every week.

Cooler maintenance practically eliminated by switch to Sun Quenching Oil Light

A leading automotive manufacturer reports a drastic reduction in his cooler maintenance. No heavy sludge deposit forms in cooler coils, because Sun Quenching Oil Light has natural detergency and solvent action that *keep coolers clean.*

IT'S VERSATILE. Sun Quenching Oil Light can be used in any type of quenching-oil system. It has uniform quenching properties and low drag-out.

IT'S ECONOMICAL. Sun Quenching Oil Light can save you money two ways—in low initial cost and in reduced maintenance.

For full information, call your Sun representative or write to SUN OIL COMPANY, Philadelphia 3, Pa., Dept. MP-4.

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INDUSTRIAL PRODUCTS DEPARTMENT

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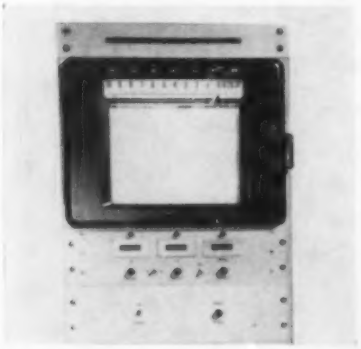
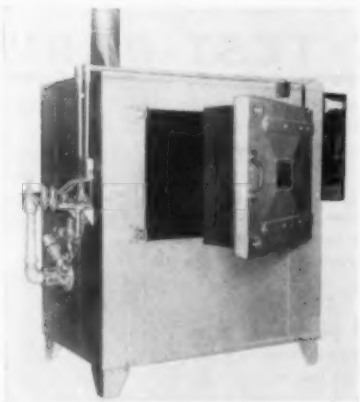
conventional watt-hour meter. A transmitting slidewire in the recorder provides a means of supplying a low voltage a.c. signal to an electronic



amplifier which in turn provides a signal to the current coil of the watt-hour meter. With the signal being proportional to the recorder pen position, the rotation rate of the disk of the watt-hour meter is also proportional to the recorder pen position.
For further information circle No. 724 on literature request card, page 48-B.

Recirculating Furnaces

A line of 1000° F. recirculating furnaces for solution heat treating and similar processes has been announced by Grieve-Hendry Co. Standard models are available for either electric or gas heat. Work chamber dimensions for the model shown below



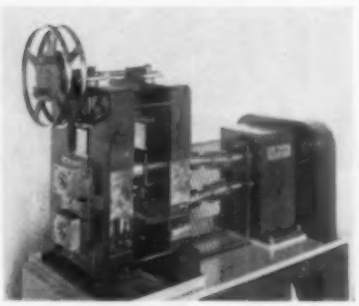
are 38 by 20 by 26 in. high. A 150,000 Btu. gas burner is installed. Recirculating air blower is driven by a ¾ h.p. motor.
For further information circle No. 725 on literature request card, page 48-B.

Paint Stripping

A low-temperature solution for rapid paint stripping of production-line finish rejects has been announced by the Kolene Corp. It will remove all types of modern organic finishes, including epons, modified epons and acrylics. It is used at 260 to 275° F. Kol-Strip is nonflammable, fast acting, and dissolves the resins and separates the pigments which settle to form a removable sludge.
For further information circle No. 726 on literature request card, page 48-B.

Rolling Mill

A 2-high/4-high combination rolling mill for metallurgical production and research work has been announced by Loma Machine Mfg. Co. Heavy-duty design allows the mill to make reductions of more than 50% per pass while maintaining thickness tolerances of 5%. Change-over from the 6 by 8 in. 2-high to the 1½ and 6 in. by 8 in. 4-high set-up requires 20 min. The



2-high arrangement is used for either hot or cold breakdown rolling of plate and sheet. With the 4-high set-up, strip is cold finish rolled to gages as thin as 0.001 in.
For further information circle No. 727 on literature request card, page 48-B.

Low-Melting Alloys

Empire Metal Co. has announced low-melting or fusible alloys in rod or wire form. These shapes are especially suitable where these materials are used as solders or as fillers or fusible plugs, escape valves and such products. Soldering or metal spraying can be carried on using regular soldering or continuous spraying guns. These rod or wire alloys are available in diameters of ⅛ through ⅝ in. and in melting points from 100 through 450° F.
For further information circle No. 728 on literature request card, page 48-B.

Ultrasonic Cleaner

Alcar Instruments has announced a new 2-kw. ultrasonic cleaner for small part cleaning, blind-hole washing, removal of radioactive contamination, printed circuit cleaning and similar cleaning operations. Nickel transducers are welded into the bottom of a stainless steel tank, 9 by 14 by 13 in. in size. Water cooling of the transducers allows the use of

HARRIS HELPS... HOOVER

ASSURE DIMENSIONAL STABILITY OF TOOLS AND GAGES

Ernest U. Day, Foreman of Hoover's Tool Department, applauds the performance of their Harris 6 cu. ft. heavy-duty chilling machine for achieving "more accuracy and more stability", the two prime objectives of tool and gage fabrication.

A Harris Chilling Machine during the past two years has solved the serious problem of achieving dimensional stability in steels for gages in the Tool Department of the famous Hoover Company, North Canton, Ohio, leading manufacturer of vacuum cleaners. Chilling has also proved a quicker and more positive method for shrink-fits on die assemblies.

Super-chilling at –130° to –150° F and tempering will achieve 100% transformation of austenite to martensite in water and oil-hardening steels, ideally suited for gages but slightly sluggish to austenitic decomposition.

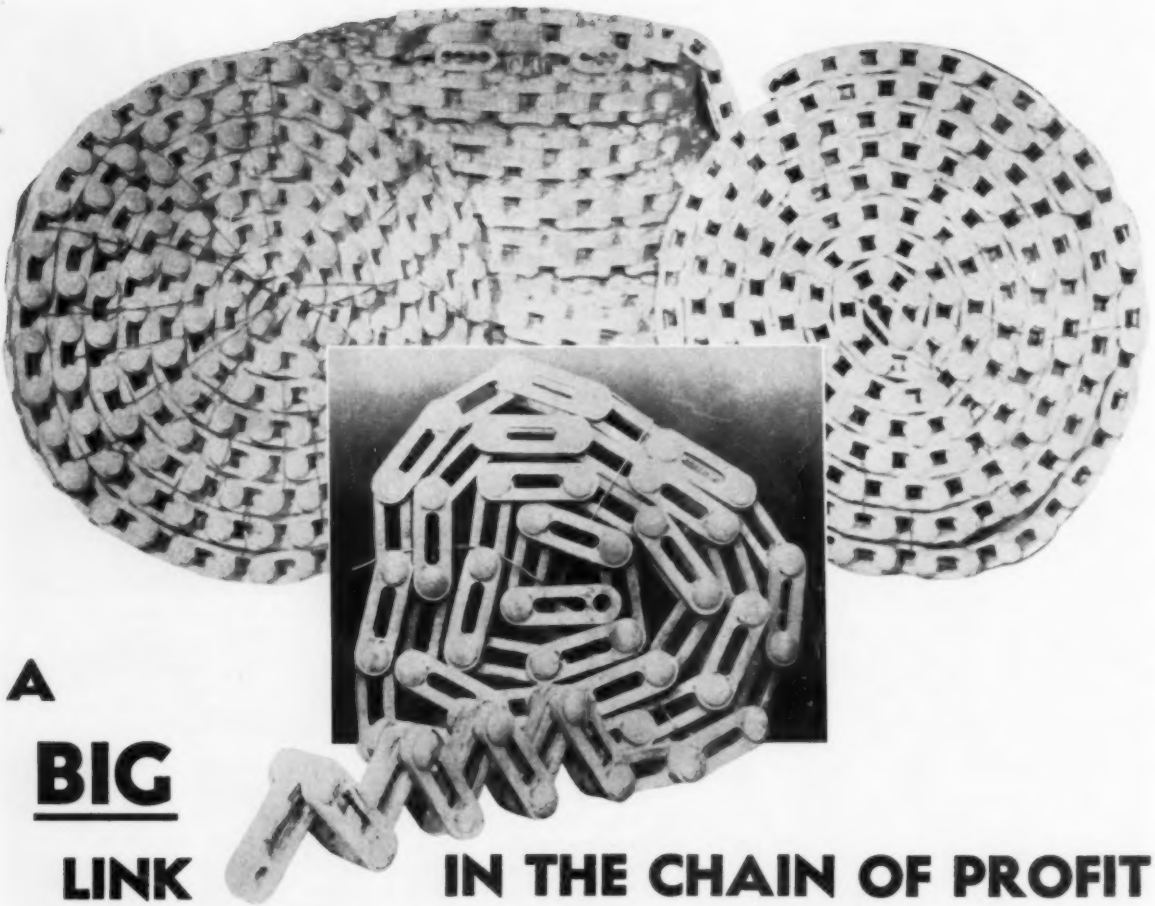
A super-chill also increases Rockwell hardness by several points in high-carbon, high-chrome steels, needed for dies but also sluggish in transformation.

LEARN HOW CHILLING CAN IMPROVE YOUR TOOLS AND PRODUCTS . . . AT LESS COST. WRITE TODAY OR SUBMIT SAMPLE PARTS FOR TEST PROCESSING. NO OBLIGATION.

HARRIS REFRIGERATION CO.

308 River St., Cambridge 39, Mass.

Specialists in refrigeration engineering, manufacturing, and service since 1934.



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EVERY LINK IS A "FATIGUE TEST-BAR"

Their *"predictably uniform"* SERVICE-Fatigue-Life, determines your FACTUAL alloy COST, (Heat Hrs. per $). A 1% failure, a single "WEAK LINK", means PRODUCTION INTERRUPTION, that could cost you over 100% of the alloy price.

FATIGUE-LIFE is determined by Metallurgical INTEGRITY, by as-cast *Structures-Properties*. For predictable grain-size and orientation, (i.e. Structures-Properties), between castings, and within individual castings, SPECIFIC highly ADVANCED Technology, processes and CONTROLS are *MANDATORY*. These proprietary developments *differ widely* from conventional "foundry practice".

UNIQUE AND UNPRECEDENTED A.E.C. Co. Casting Process and Product Research & Development Projects, for three branches of the U.S. Armed Services, and privately, during and since W.W. 2, are not remotely approached in scope, depth, and extent of effort, by companies, or trade associations, in the Alloy, or steel casting industry.

Eliminate "Weak Links" in your production line. Let A.E.C. Co. Engineers help bring your High Temperature Tooling up to the level of your Machine Tooling. We solicit your inquiries.

HEAT RESISTANT CASTINGS
ACCOLOY
STAINLESS STEEL CASTINGS

ALLOY ENGINEERING & CASTING CO.

1700 W. Washington — Phone: 6-2568

CHAMPAIGN • ILLINOIS

ENGINEERS AND PRODUCERS OF HEAT AND CORROSION RESISTANT CASTINGS

cleaning solutions up to 450° F. A 0 to 15 min. timer is provided or the timer can be by-passed to permit continuous operation.

For further information circle No. 729 on literature request card, page 48-B.

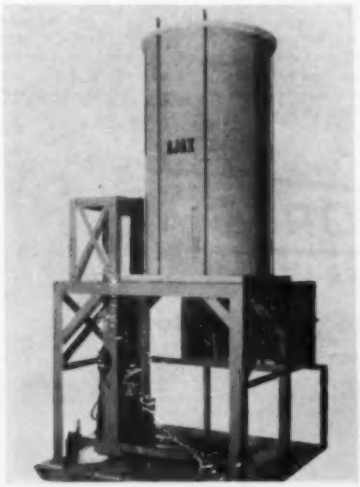
Thickness Gages

American Tradair Corp. announces British made beta-ray thickness gages. Two models are available: the twin-channel Model N562 for high-speed production line use, and single-channel Model N565 for laboratory and short-run production applications where sheeting or coating densities change with each job order. Measurement ranges from 4 to 12,500 grams per square millimeter, depending on beta source used.

For further information circle No. 933 on literature request card, page 48-B.

Carbide Sintering

A new carbide sintering furnace with high-frequency induction heat has been announced by Ajax Electrothermic Corp. It is designed for bottom loading. A platform swings out, is loaded and swings back beneath the furnace. Then, a hydraulic lift

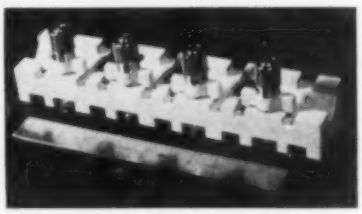


carries the material up and into the furnace. The furnace can be operated at temperatures of 4500° F. and over, and under special atmospheres if desired.

For further information circle No. 934 on literature request card, page 48-B.

Furnace Brazing

High-temperature ceramic fixtures to be used for furnace silver brazing have been announced by Duramic Products, Inc. Sur-Braze M120-F is a fired aluminum silicate with heat resistance to 2000° F. A typical furnace brazing fixture designed to braze



four assemblies simultaneously is shown above. Dimensions are 7 in. long by 1½ in. wide.

For further information circle No. 935 on literature request card, page 48-B.

Heat Treat Basket

A heat treat basket combining longitudinal strength and lateral support without welding has been announced by the Bix Co. Because of its

articulated design, it expands and contracts independently. Custom-made baskets can be adapted to any special requirement.

For further information circle No. 936 on literature request card, page 48-B.

Tubing

The Jones & Laughlin Steel Corp., has announced smooth inside surface finish on electricweld steel tubing. This cold-drawn tubing has an inside diameter to 3½ in. and a wall thickness of 3/16 in.

For further information circle No. 937 on literature request card, page 48-B.

Brinell Tester

The King Tester Corp. has announced a new model Brinell tester designed especially to make end tests on cylinders, die blocks and large castings. The machine can test a part 29 in. or more in height and has a

℞ TREAT ALUMINUM RIGHT with these proven AHCO Compounds

Lustralume No. 1 ℞

This new burnishing compound is a clear, stable liquid readily soluble in water. It's non-toxic and non-flammable . . . ideal for use in all conventional types of oblique or horizontal barrels where moderate foaming is permissible.

Ahcal Etch Cleaner No. 1 ℞

This cleaner produces an attractive, uniform etch in a short time on all types of aluminum surfaces. Ahcal's outstanding advantage is its ability to dissolve large amounts of aluminum without forming undesirable scale or sludge.

Ahcal Deoxidizer ℞

Ideal to remove smut after cleaning and etching, and before painting. Its convenient powdered form makes it safer than liquid acids.

Ahcoloid Cleaners ℞

- 189—A non-etching alkaline soak cleaner.
- LC-3—An emulsifiable liquid pre-cleaner to remove oil, grease, and buffing residues.
- 59-H-5—A cleaner for power washers.
- LUSTREBRITE LIQUID 35—A new liquid soak cleaner developed specifically to remove buffing compound residues and fingerprints.

Hubbard Hall

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APOTHECARIES HALL CO.

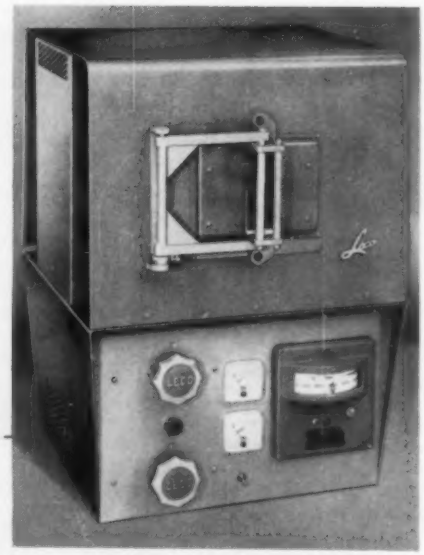
DIVISION OF

THE HUBBARD-HALL CHEMICAL COMPANY

WATERBURY, CONN.

Leco designs new furnaces around Norton "HOT RODS"

Leading lab furnace builder reports longer life and other advantages of CRYSTOLON* heating elements



The new LECO Model 542 Box Furnace — equipped with long-life CRYSTOLON heating elements — is shown above. Other new Hot Rod-equipped LECO furnaces include two tube and four tube models.

LECO Laboratory Equipment Corporation
Manufacturers of Precision Control Equipment
St. Joseph, Michigan

January 15, 1958

Norton Company
Worcester 6, Massachusetts
Attention: Mr. W. H. Davenport
Refractories Sales Engineering Dept.

Gentlemen:

At LECO we have been so impressed by the advantages of CRYSTOLON heating elements that we have designed our complete new line of resistance furnaces around them.

When these new furnaces were exhibited at recent trade shows, they created an overwhelming amount of interest. Our customers and prospects were particularly impressed by the fact that two years of field tests revealed that CRYSTOLON elements have far superior life to ordinary elements.

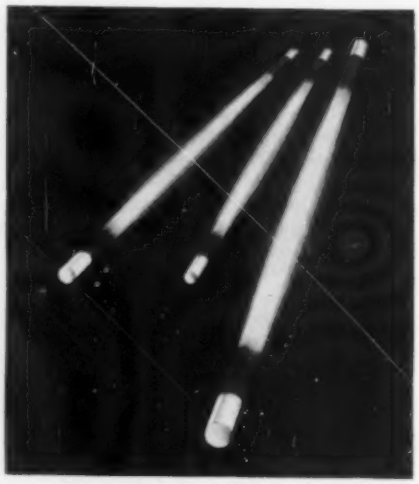
As you know, the way for a firm to advance is to bring progress to its customers, and we really feel we are bringing the latest in technological advances to our customers with Norton Hot Rods.

Very truly yours,
LABORATORY EQUIPMENT CORPORATION

H. J. Schmitt

H. J. Schmitt
General Sales Manager

HJS: rm
Enc.



CRYSTOLON Heating Elements, or "Hot Rods", are a typical Norton ℞ — an expertly engineered refractory prescription for greater efficiency and economy in electric furnace and kiln operations. Made of self-bonded silicon carbide, each one-piece rod has a central hot zone and cold ends. Aluminum-sprayed tips and metal-impregnated ends minimize resistance and power loss. Available in standard sizes.

Similar reports from many other plants mean that you, too, can save with "Hot Rods" because their extra lor life greatly reduces replacements. Also, you get reduced maintenance due to less changing of elements and voltage taps. One-piece, non-welded "Hot Rods" are strong and straight . . . help protect product quality because their slow, evenly matched rate of resistance provides more uniform heating quality . . . and they are packed shockproof to reach you unbroken. For further facts send for booklet *Norton Heating Elements*. NORTON COMPANY, Refractories Division, 323 New Bond Street, Worcester 6, Massachusetts.

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Making better products . . . to make your products better

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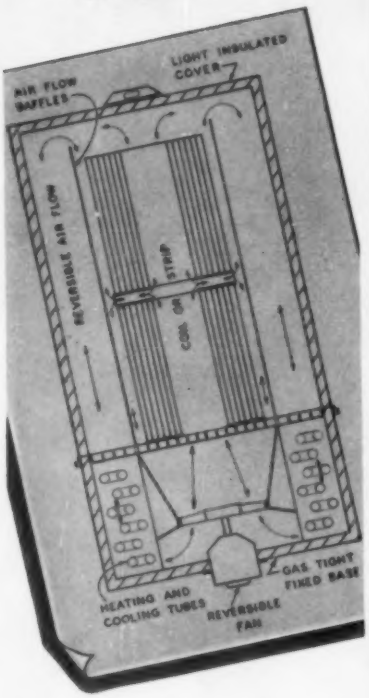
Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

CUT NON-FERROUS ANNEALING TIME 33%



R-S Single Stack* Annealing... Faster Heating, Automatic Airflow Reversal... Uniform Heating

Designed for faster heating and cooling with forced convection and automatic airflow reversal—allows absolute uniformity of heating with no spotty sections on coils.

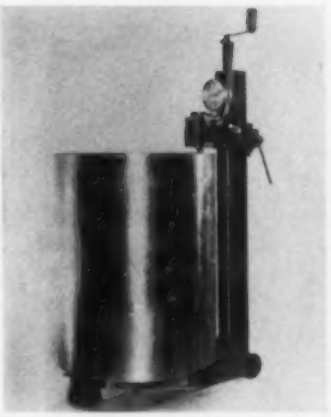
Lightweight, insulated, one-piece cover. Permanent fuel-air connections. Annealing of copper, brass and bronze strip and wire accomplished in only ⅓ of time required for conventional annealing. Only one seal to maintain with one cover to handle. Factory assembled unit with true portability.

Write for details on strip and wire annealing.

R-S FURNACE CO., INC.
NORTH WALES, PA.

*Patent Pending

R-S FURNACES



throat of 3½ in. It weighs only 45 lb. and can be used in any position. It uses a 5 mm. or 10 mm. carbide ball at any load ranging up to 3000 kg.

For further information circle No. 938 on literature request card, page 48-B.

Ultrasonic Soldering

Gulton Industries has announced an ultrasonic soldering iron, designed for soldering aluminum and magnesium and their alloys without flux, and for

other uses where it is necessary to avoid the corrosive effects of a flux. Ultrasonic vibrations break the oxide layer of metals that form refractory oxides. The instrument can be used with electric or gas heated soldering tips.

For further information circle No. 939 on literature request card, page 48-B.

Ultrasonic Cleaner

Acoustica Associates, Inc., has announced a 150 gal. ultrasonic cleaning system. A cleaning tank 3 ft. square by 2½ ft. deep is fitted with 20

bottom-mounted transducers which are driven by a simplified pulsed electronic generator delivering 8000 watts

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PIONEER IN

CHROMATES

NOW OFFERS DECORATIVE

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These are not just spotty indentification colors. These are scintillating golds, yellows, blues, greens, violets, reds, brass and copper hues that will add glamor and sales appeal.

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WALTHAM AVE., SPRINGFIELD, MASS.

Interior of Kemp Melting Pot

For the inside story on low-cost melting pot operation . . .

Come to Kemp

One 15 ton Kemp Immersion Melting Pot tempers 650 feet of steel strap a minute at Signode Steel Strapping Co., Sparrows Point, Md. High production schedules are maintained with substantial savings in fuel and down-time.

Kemp, the pioneer in immersion heating, can show you documented proof of the efficiency and economy of Kemp Immersion Heating Pots. For dipping, coating, and annealing in solutions, soft metals, and salts; Kemp units provide the precise control and economical operation that gives you a better product at lower cost.

Kemp Gas-Fired Immersion Heating Units put an end to cracked pots, costly heat losses . . . give you uniform heat distribution, quick recovery and high capacity. Kemp heating elements *inside* the pot transfer heat directly to the material being heated. There is no exposed flame, and radiation losses are minimized. You get accurate and sensitive temperature control, without overrun or lag.

Kemp pots are available in capacities from 1 to 75 tons, with melting rates up to 26 tons per hour. Your Kemp Representative will give you full details; or write us direct for Bulletin IE-11. The C. M. Kemp Mfg. Co., 405 East Oliver St., Baltimore 2, Md.

Kemp Convection Dryers

Kemp Inert Gas Generators

KEMP OF BALTIMORE

Kemp Industrial Carburators

Kemp Orlad Dryers

New Athey PW20 dump trailer built 11,000 pounds lighter with USS "T-1" Steel; has lower operating costs and new 3rd (or rear) door design.

Hauls payload over 3½ times its own weight!

—built entirely from USS "T-1" Steel

This new Athey Bottom Dump Trailer is unique. It weighs only 22,500 pounds but has a payload capacity over 3½ times as great: 80,000 pounds. According to the manufacturer, this high ratio of payload to weight is unequaled by any similar equipment.

Trailer weight reduced by 11,000 pounds. That's a lot of weight to take out of a trailer, but the job was done by using USS "T-1"* Steel throughout. This steel has high impact abrasion resistance and nearly three times the yield strength of structural carbon steel. This permitted reduction in plate thicknesses and a weight saving of 11,000 pounds. There was no sacrifice of strength or ability to take punishment.

Ready weldability. The trailer is all-welded, and the USS "T-1" Steel retains its superior strength and toughness after welding—at temperatures even down to 50 below zero. Thus, all parts of the body including the drawbar can be welded without loss of strength.

Build better with USS "T-1" Steel. No other steel possesses the remarkable combination of high yield strength (90,000 psi), toughness and weldability found in USS "T-1" Steel. When you also consider the high resistance to impact abrasion, you have a steel that will save money on construction and mining equipment. For more information, write United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

Remember that we also make USS COR-TEN*, USS TRI-TEN* *and* USS MAN-TEN* *Steels . . . standards for heavy-duty equipment.* *Registered trademarks.

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Warehouse Distributors
United States Steel Export Company

USS United States Steel

You're looking at the largest forged plate-bending roll ever made

You can never be certain about these things, but we think that the USS Quality Forging in the picture *is* the largest roll ever made for a heavy plate-bending machine. Three of these rolls are arranged in a pyramid, with one alloy steel roll assembled above two carbon steel grooved rolls. A steel plate is rolled back and forth between top and bottom rolls, and the plate is bent as the top roll is tightened down on the bottom two.

As you see it in the 10,000-ton press at our Homestead Forge Shop, the roll is 30″ in diameter and about 60 feet long. You have to use very special techniques to handle a forging of this size during the forging and heat treatment operations

—but the specialists who produce USS Quality Forgings really know how to do it.

After forging, the machining presented some interesting problems. The work surface, or face, of each bottom roll is about 480″ wide, and is tapered from a 30¾″ diameter at the center to 30$\frac{5}{16}$″ at the ends. Twelve longitudinal grooves are machined in each bottom roll, equally spaced around the roll body circumference. The grooves are ¼″ wide by $\frac{5}{16}$″ deep, and they improve the grip on each steel plate as it is rolled back and forth in the bending machine.

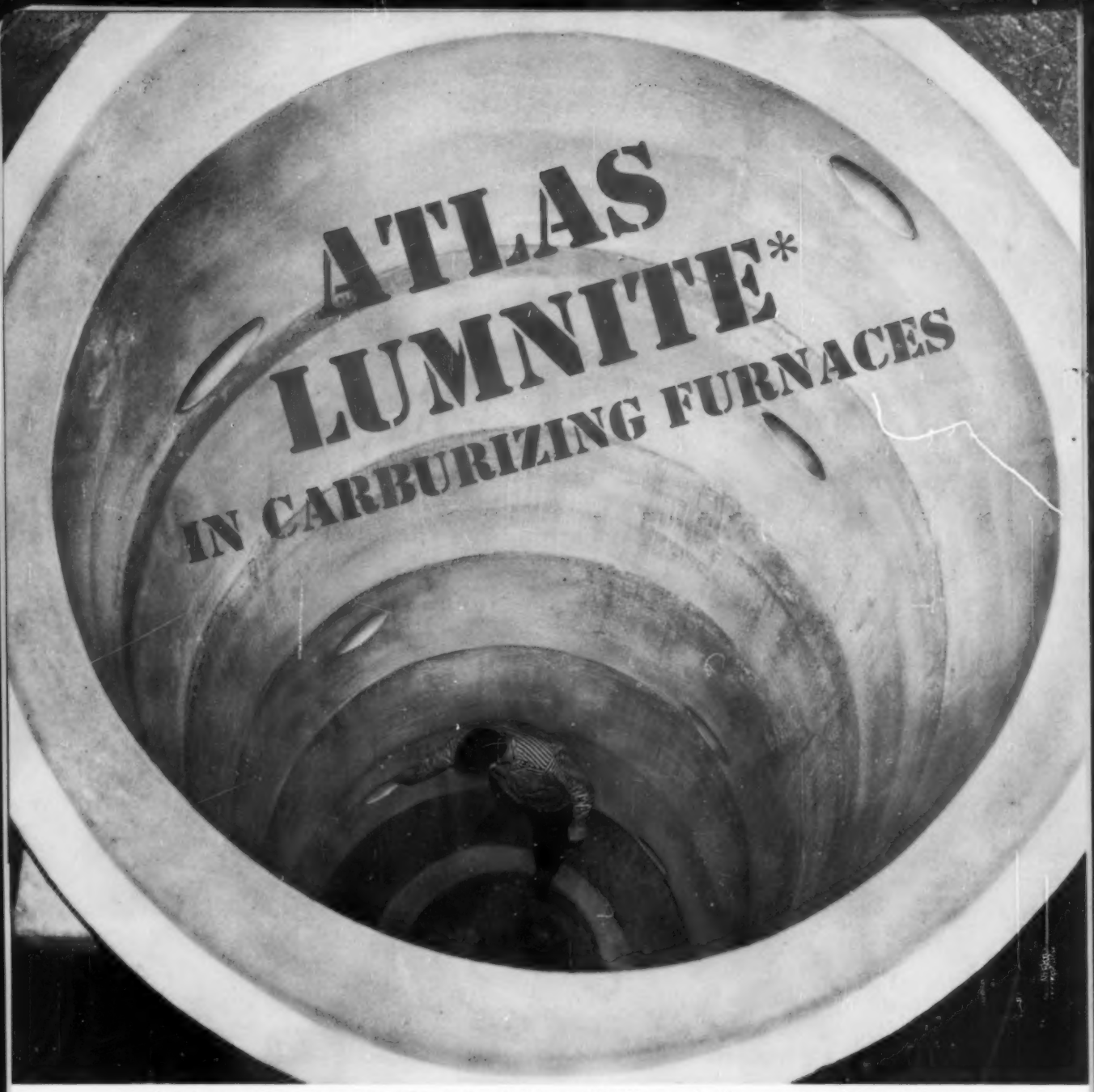
There are only a few places in the world where you can get forgings like this, and United States Steel is the *one* place where you can get that extra bit of skill that distinguishes a USS Quality Forging. And don't forget that in this instance we made the steel, forged, heat-treated and machined it in one plant.

We'll appreciate your inquiries or requests for our free 32-page booklet on USS Quality Forgings. Please write United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS is a registered trademark

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Export Company

USS **United States Steel**



Vertical pit-type carburizing furnace (9' x 24') lined with an insulating castable refractory made with LUMNITE cement. Operating temperature to 1800° F. Badall Engineering & Manufacturing Co., Hammond, Ind. Castable used: "Kast-O-Lite," product of A. P. Green Fire Brick Co., Mexico, Mo.

"...withstands thermal shock...reduces heat loss,"

says Fred F. Badalli, Badall Engineering & Manufacturing Co.

- Refractory concrete linings (made with LUMNITE calcium-aluminate cement and selected aggregates) resist furnace temperatures to 2600° F . . . protect against thermal shock due to heating-cooling cycles . . . provide insulation.
- Construction is fast, easy, economical. Linings can be cast in place, troweled or "gunited" . . . service strength is reached in 24 hours.

For maximum convenience, use castables made with LUMNITE cement. These are packaged mixtures, ready for use. Just add water, mix and place. Made and distributed by leading manufacturers of refractories.

For literature on refractory concrete, write:
Universal Atlas, 100 Park Avenue, New York 17, N. Y.

"LUMNITE" is the registered trade-mark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company

UNIVERSAL ATLAS CEMENTS

USS TRADE-MARK

L-118

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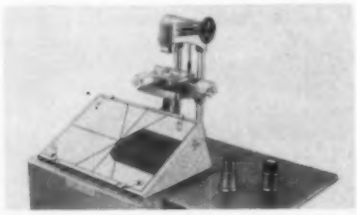
OFFICES: *Albany · Birmingham · Boston · Chicago · Dayton · Kansas City · Milwaukee · Minneapolis · New York · Philadelphia · Pittsburgh · St. Louis · Waco*

peak power. Either solvent or detergent solutions can be used.

For further information circle No. 940 on literature request card, page 48-B.

Microprojector

Opto-Metric Tools, Inc., has announced a new floor model microprojector. This model is self-contained and self-supporting. It is available in



six selective magnifications and with a choice of three different measuring stages, centers, surface illumination, protractor and measuring screens.

For further information circle No. 941 on literature request card, page 48-B.

Ferrosilicon

Electro Metallurgical Co. has announced a new pig-cast form of 75% ferrosilicon. Heretofore, this material has been supplied in mixed lumps varying in size from 75 lb. down to 2 in. The pigs weigh between 20 to

NEW REICHERT **Research METALLOGRAPH**

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Low Power Photography
Phase contrast for Metallography
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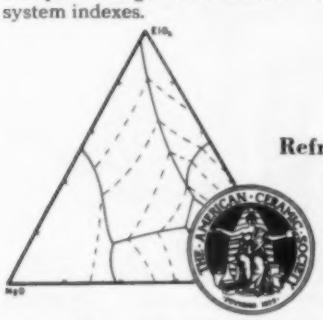
For complete specifications and prices, write for Bulletin "MeF" to:

WILLIAM J. Hacker & CO. INC.

82 Beaver St., New York 5, N.Y. / 1717 North Garrett St., Dallas 6, Texas

Phase Diagrams for Ceramists. ERNEST M. LEVIN, HOWARD F. McMURDIE, AND F. P. HALL. Edited and published by the American Ceramic Society, Inc., Columbus 14, Ohio, 1956. 286 pp. $10—This enlarged and revised edition contains eight hundred and eleven phase diagrams covering (a) metal oxide systems, (b) systems containing nonmetal oxides, (c) systems containing halides, sulfides, etc., and (d) water-containing systems. The general discussion includes (1) an enlarged glossary of about 50 terms; (2) a comparison of the three important temperature scales, in degrees centigrade, that have been used since 1914; (3) methods for determining the composition of phase assemblages; (4) interpretation and representation of multicomponent systems; and (5) a selected and annotated bibliography on the various aspects of phase research covering theory, interpretation, method and techniques, mathematical treatment, thermodynamic calculations, silicate chemistry, and phase diagrams in related fields. Complete author and system indexes.



Other volumes on ceramic science:
Refractories Bibliography
Enamel Bibliography and Abstracts

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Metal Cutting Knives *ONLY*

We offer forty years of experience in producing the highest quality Metal Cutting Knives and skilled craftsmen working with the finest materials to exacting tolerances.

A bulletin on "Metal Shearing Aids" will be sent on request.

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1201 West 65th St. • Cleveland 2, Ohio

BURRELL *"For Scientists Everywhere"*

LABORATORY TUBE FURNACES

For carbons and sulfurs at high temperatures

Newest, most advanced design for fast determination of carbon and sulfur by combustion in all ferrous metals.

Burrell Tube Furnaces operate at the highest temperatures possible with silicon carbide elements.

Drawer-Type Panels for Ease of Access

Instrument panels pull out for ease of inspection, parts replacement and servicing when necessary. All electric components are mounted on the easy-access panel.

Cat. No.	FURNACE	Price
24-934	One-Tube Furnace, Model H-1-9	675.00
24-944	Two-Tube Furnace, Model H-2-9	700.00
24-954	Four-Tube Furnace, Model H-4-9	1000.00

For use with 115 or 230 volts, 60 cycle, as specified.
Prices listed are F.O.B. Pittsburgh, Pa.

Ask for Bulletin No. 310

BURRELL CORPORATION

Scientific Apparatus and Laboratory Supplies

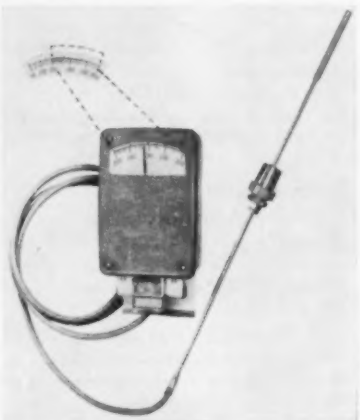
2223 FIFTH AVENUE, PITTSBURGH 19, PA.

25 lb., and are approximately 9 in. square at the top, 6 in. square at the bottom, and 4 in. thick. The relatively uniform lump size of the alloy will aid in achieving fast solubility of ferrosilicon additions in steel melting operations.

For further information circle No. 942 on literature request card, page 48-B.

Temperature Transmitter

An indicating temperature transmitter, for pneumatic transmission of temperature measurement in ranges from 100 to 600°F., with spans of 100 and 200°F., has been announced by the Foxboro Co. Indication at point of measurement is accomplished by red pointer and



black-on-white scale markings with widening divisions across upper portion of range, providing visibility at 20 ft. The transmitter is 10⅛ in. high, 5⅞ in. wide and 4⅛ in. deep and weighs 10 lb.

For further information circle No. 943 on literature request card, page 48-B.

Salt Bath Pot

A neutral salt bath furnace pot nearly 7 ft. high and 36 in. in diameter has been announced by Rolock, Inc. The bottom is ½ in. thick and the sides ⅜ in. thick.

For further information circle No. 944 on literature request card, page 48-B.

ACHESON

dispersions digest

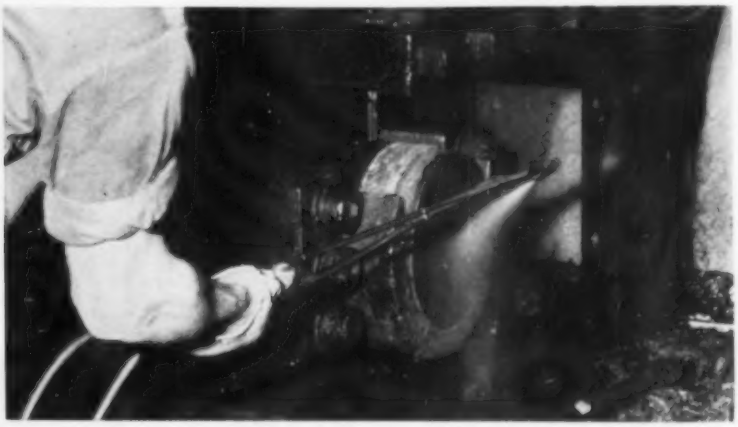
Reporting uses for

dag® BRAND DISPERSIONS

COLLOIDAL GRAPHITE, MOLY-SULFIDE, VERMICULITE, AND OTHER SOLIDS

WHY 'DAG' DISPERSIONS MEAN *PERFORMANCE* IN ALUMINUM EXTRUDING

The excellent lubricating properties of Acheson Colloidal Graphite, under conditions of extreme heat and pressure have been confirmed by leading extruders of aluminum, steel, copper, brass, lead and other metals. Water-base dispersions of colloidal graphite used in the following application histories have provided savings in material handling, reduced maintenance time and expense, prevented seizure, extended die life, and produced extrusions of more uniformly high quality. Any one of these benefits should make profitable reading for you.



For faster, more uniform application with less material consumption, Aluminum Extrusions, Inc. finds 'Aquadag' their best die lubricant.

A little 'Aquadag' goes a long way for Aluminum Extrusions, Inc., Charlotte, Michigan. This company, one of the leading independent extruders in the country, has found that by applying 'Aquadag' on die surfaces they have effected a 30% savings in their material handling. Formerly, they had used an oil-graphite mixture which required a dilution ratio of 16 lbs. of graphite to a 55 gallon drum of oil. It was too slowly applied by swab and too coarse to apply by spray with any degree of efficiency.

With 'Aquadag', Aluminum Extrusions has a lubricant that is finer in particle size, permits wider coverage, and provides greater "sprayability". These minute particles pass freely through the spray nozzle, eliminating the costly downtime formerly involved in cleaning clogged equipment. The tough, dry film 'Aquadag' forms upon the evaporation of its water carrier, doesn't smoke or react when applied to hot dies and metals. This improves working conditions as well as extends die life. Important also to both die surfaces as well as the finished extrusion, is the fact that this durable, low-friction film allows easier, more uniform metal flow.

Considered in relation to the over 12 million pounds of aluminum extruded yearly at this plant . . . 85% of it in fabricated form . . . *'Aquadag' has brought important production efficiencies and material economy* to Aluminum Extrusions, Inc. In many, similar instances where product quality and basic economy are demanded, Acheson colloidal dispersions have gained ready acceptance.

Exclusive Acheson processing techniques guarantee a consistently uniform top-quality product. If your problem is more effective lubrication under normally adverse conditions of extreme temperature, pressures, or abrasion, call in your Acheson Service Engineer.

Dies last three times longer with 'Aquadag', according to another prominent midwest extruder. Metal pickup on the extruding dies has been completely eliminated by the use of this Acheson dispersion, extending the effective use of the dies from 1000 to 3000 strokes. The evaporation of its water-base leaves a dry, adherent "graphoid" film on all lubricated surfaces, inhibiting the build-up of abrasive precipitates. At the same time, the unbroken, microscopically-thin film that 'Aquadag' provides, facilitates metal flow and reduces scoring to a negligible minimum. Application of the lubricant is by spraying a dilution of 1 part 'Aquadag' to 20 parts water, on the die surface before each "push" of the extrusion press.

A 'dag' graphite coating is also applied to the follow blocks on this company's 1400 ton horizontal extrusion presses. For purposes of even greater economy, 'Prodag' — semi-colloidal graphite in water — is used in this application. This effective parting agent prevents the flash, back-extruded from the billet skin, from locking the butt to the follow block. An Acheson dispersion is very possibly the answer to your lubricating troubles. For additional information, write for your free copy of Bulletin 426. Address Dept. MP-48.

Extended die life and extrusions with more perfect surface finish, are attributed to the use of 'Aquadag'.

ACHESON *Colloids Company*

PORT HURON, MICHIGAN

A division of Acheson Industries, Inc.

Also Acheson Industries (Europe) Ltd. and affiliates, London, England

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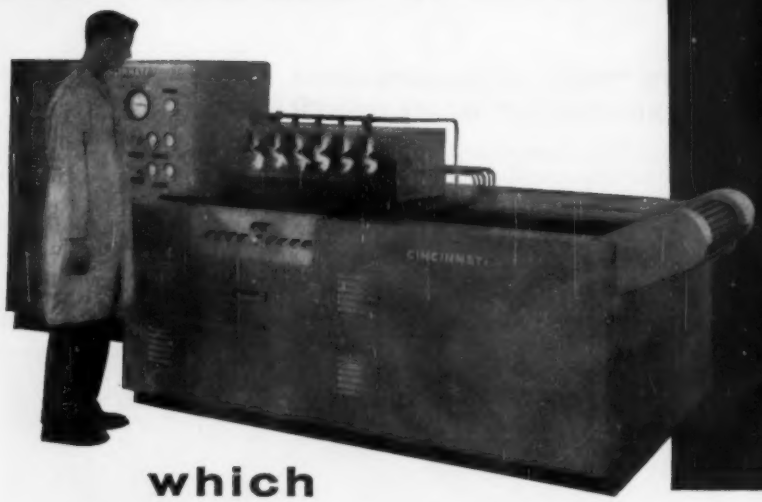
Offices in: Boston • Chicago • Cleveland • Dayton • Detroit • Los Angeles • Milwaukee New York • Philadelphia • Pittsburgh • Rochester • St. Louis • Toronto



New CINCINNATI

flamatic®

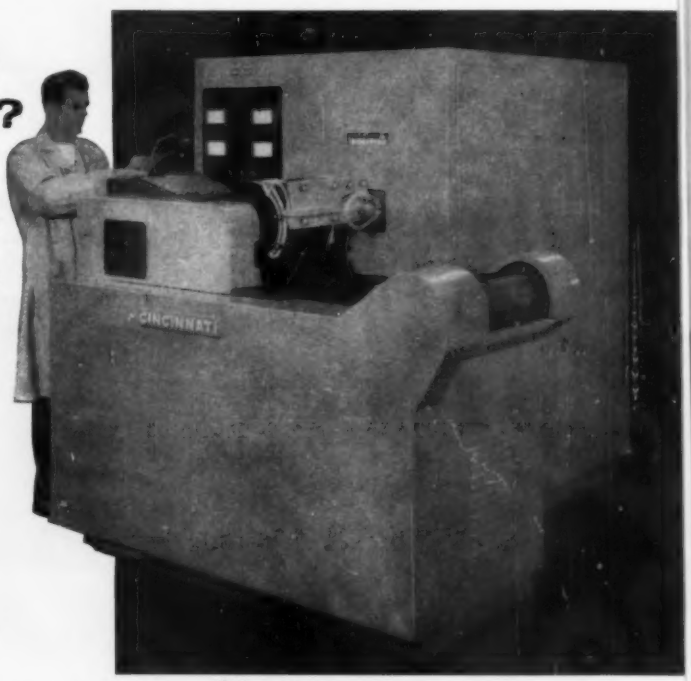
In production, the machine shown uses multiple fixtures for selective surface hardening *1000 automotive rocker arms per hour.*

which

CINCINNATI

meets your selective surface hardening needs?

Your product components that require heat processing—such as selective surface hardening, annealing, brazing, tempering—can be Cincinnati-processed at a savings! New and versatile Cincinnati flame or induction heating machines can do the work you specify—and meet your cost-per-piece requirements-on high production quantities or varied, small-lot runs. Let a Process Machinery Division field engineer evaluate your needs. With the assistance of our extensive research laboratories and engineering facilities, he is ideally equipped to recommend the heat source and method that will be best and cheapest for you.



See these two machines in operation, ASTE Show, Booth No. 1555, Philadelphia Convention Center, May 1 through 8.

New CINCINNATI

inductron®

This machine induction hardens both ends of *automotive push rods at the rate of 3600 parts per hour.*

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hardening machines

Meta-Dynamics Division

THE CINCINNATI MILLING MACHINE CO.

CINCINNATI 9, OHIO, U. S. A.

APPLICATION and EQUIPMENT new literature

730. Abrasive Cleaning
Catalog 57-WX on brush types, sizes, speeds, filaments. Aids to power brush selection. *Pittsburgh Plate Glass*

731. Air Washers
Bulletin No. 256 on acid-proof air washers for ventilation systems. Construction and accessories. *Automotive Rubber*

732. Alloy Steel
68-page "Aircraft Steels" includes revised military specifications. Also stock list. *Ryerson*

733. Alloy Steel
Data book on the selection of the proper alloy steel grades for each manufacturer's needs. *Wheelock, Lovejoy*

734. Aluminum
24-page data book on high-strength aluminum - zinc - magnesium - chromium - titanium alloy. Properties, aging, corrosion. *Frontier Bronze*

735. Aluminum Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

736. Aluminum Extrusions
Folder lists alloys used, finishes, trade phraseology. *General Extrusions*

737. Aluminum Extrusions
Catalog of stock extrusion dies. *Jarl Extrusions*

738. Arc Welding
Revised 24-page Catalog 2300 on equipment for inert-gas-shielded tungsten arc welding process. Manual and automatic units. *Air Reduction*

739. Atmospheres
Bulletin 1-10 supplies technical information on inert gas generators and data on costs. *C. M. Kemp Mfg.*

740. Bimetal Applications
44-page booklet, "Successful Applications of Thermostatic Bimetal", contains uses, formulas, calculations. *W. M. Chace*

741. Blast Cleaning
Complete information on Malleabrasive for cleaning and finishing. *Globe Steel Abrasive*

742. Blast Cleaning
New 16-page Bulletin 226 on blast cleaning equipment. Describes continuous operation which is wholly automatic. *Pangborn*

743. Boron Stainless
8-page booklet on composition, structure, corrosion resistance, welding and mechanical properties of 1% boron stainless steel. *Superior Steel*

744. Brazing
New 24-page Bulletin 20 on low-temperature silver alloy brazing. *Handy & Harman*

745. Brazing Alloys
New reference chart on brazing alloys that meet all Government, A.S.T.M. and A.W.S. specifications. *American Brazing Alloys Co.*

746. Burners
New Buzzer Catalog No. 1570 describes industrial gas burners, furnaces and accessories for heat treating, metal melting, soldering and drying. *Charles A. Hones*

747. Burners
Bulletin 214 on dual-fuel burner for ovens, kilns, driers, forge furnaces, heat treating and malleabilizing furnaces. *North American Mfg.*

748. Carbonitriding
28-page booklet on nature of process, furnaces, atmospheres, parts carbonitrided and properties. *Armour Ammonia*

749. Castings
Die and permanent mold castings in aluminum and zinc discussed in new brochure, "Improve Your Products! Lower Your Costs!" *Peasley Products, Inc.*

750. Chemical Milling
New 10-page booklet describes chemical milling. What it is, its advantages, applications, how it is done and to what metals. *U. S. Chemical Milling Corp.*

751. Chromate Finishing
File on chromate conversion coatings for prevention of corrosion and paint-base treatment of nonferrous metals. *Allied Research Products*

752. Chromizing
4-page folder describes how to make iron powder components resistant to rust and wear. *Chromalloy*

753. Coatings
8-page brochure describes catalytic protective coatings. Industrial usage. *Industrial Finishes Co.*

754. Cold Treatment
4-page bulletin on low-temperature treatment and equipment. *Alpha Electric Refrigeration*

755. Compressors
12-page Bulletin 126-A on application of turbo compressors to oil and gas-fired equipment used in heat treating, agitation, cooling, drying. *Spencer Turbine*

756. Controls
New Bulletin AC-3 on eleven electromechanical controls for industrial applications. *Tipptronic, Inc.*

757. Creep Testers
Pocket-size creep load calculator that determines the pounds of weight needed on weight pan when testing specimens in creep testers. *Arcweld Mfg. Co.*

758. Creep Testing
New Bulletin RR-13-56 on testing machines for creep and stress-rupture tests. Tables. *Riehle*

759. Crystallographic Instruments
Folder on powder cameras, single crystal goniometers. *Jarrell-Ash*

760. Degreasers
Folder on vapor and solvent degreasers describes equipment and advantages. *Randall Mfg.*

761. Descaling Process
8-page bulletin on sodium hydride descaling process for ferrous and nonferrous metals. *DuPont*

762. Descaling Titanium
Bulletin 25-T on salt descaling of titanium and titanium alloys. History, recommended procedure, problems. *Hooker Electrochemical*

763. Ductility Testing
Bulletin on simple method of determining ductility of materials before drawing. *Steel City Testing Machines*

764. Electric Furnaces
Bulletin No. 528 on electric furnace for investment casting. Weight of charge, melt time, power consumption for stainless, Stellite, gray iron, copper, brass. *Detroit Electric Furnace Div.*

765. Electric Furnaces
Data sheet describes and gives specifications of standard nonmetallic resistor furnaces. *Harrop Electric Furnace Div.*

766. Electric Furnaces
Bulletin HD-153 on furnaces using silicon carbide heating elements for duty to 2600°F. *Hevi Duty*

767. Electric Furnaces
Bulletin on electric heat treating furnaces gives summary of progress in furnace developments. *Holcroft*

768. Electric Furnaces
8-page Bulletin 570 on heat treating, melting, metallurgical tube, research and sintering furnaces. Custom designs for special requirements. *Pereny*

769. Electrodes
Bulletin 810 on removable submerged electrodes. Advantages. *Ajax Electric*

770. Electron Microscopy
4-page bulletin on specimen preparation for electron microscopy. *RCA*

771. Electropolisher
Theory and practice of electrolytic polishing of metallurgical samples. Describes electropolisher. Metal Digest, Vol. 1, no. 5. *Buehler, Ltd.*

772. Extrusion
Folder describes the hot extrusion process and gives its history. *Jones & Laughlin*

773. Fasteners
52-page catalog of stainless fasteners. Thread and design specifications. Composition and properties of steels used. *Allmetal Screw Products Co.*

774. Finishing
Six bulletins describing finishing compounds for stainless steel, aluminum, other metals. *Apothecaries Hall*

775. Finishing
Bulletin on Luster-On 52 conversion coating for zinc. *Chemical Corp.*

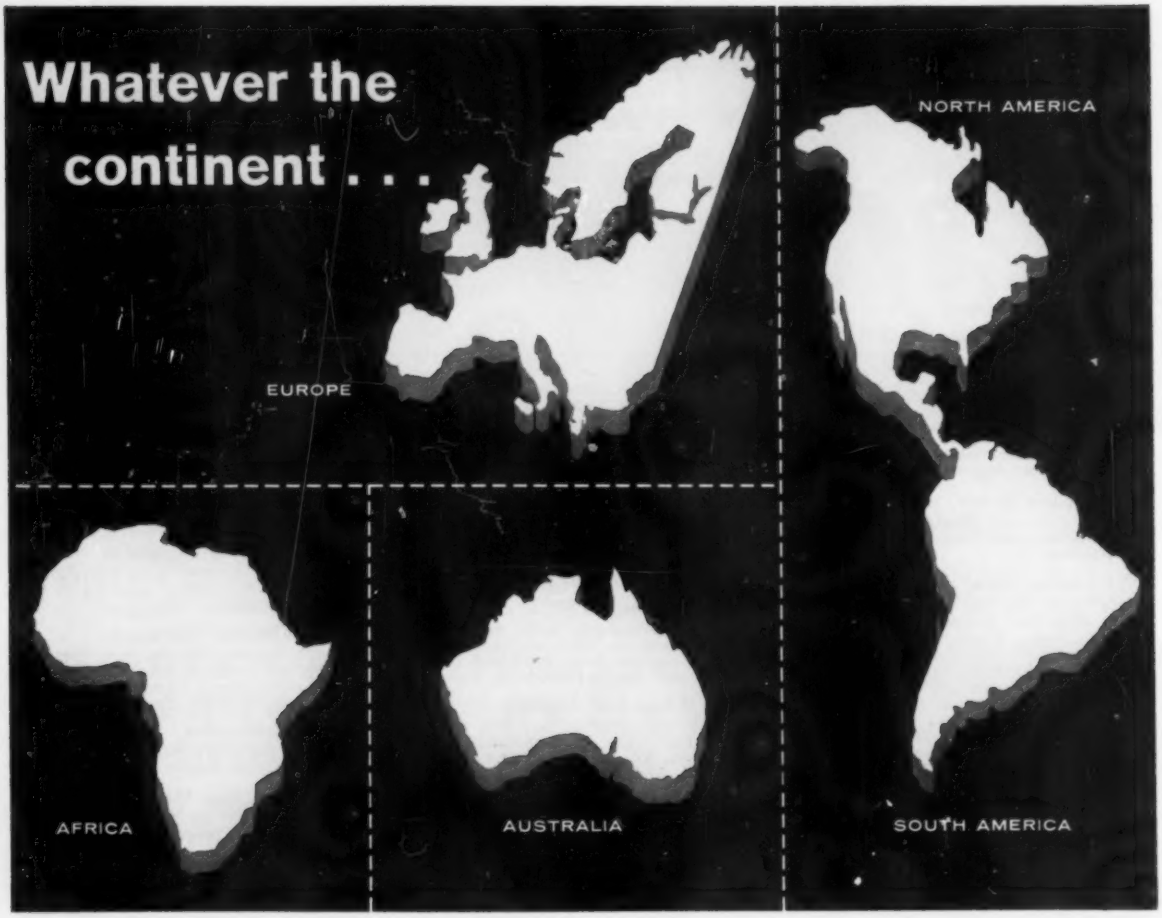
776. Forgings
Folder on facilities for production of flat-die forged products. Electronic equipment used. *Smith-Armstrong*

777. Forgings
Series of articles on modern forging methods. *Hill Acme*

778. Forgings
12-page booklet on how forged weldless rings and flanges are made. Case histories. *Standard Steel Works Div., B-L-H*

779. Furnace
6-page Bulletin No. 805 on laboratory vacuum furnace. Specifications, applications, accessories. *Kinney Mfg.*

780. Furnace Belts
44-page catalog describes metal belts



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Shell Voluta Oil is a stable high-speed quenching oil that proves ideal for use in both static and circulating quenching systems.

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for quenching, tempering, carburizing and other applications. *Ashworth Bros.*

781. Furnace Charging
12-page brochure on eight models of charging machines for heating and melting furnaces. *Salem-Brosius*

782. Furnaces
Bulletin 1250-T on bell retort furnaces describes atmosphere system, construction and dimensions. *American Gas Furnace*

783. Furnaces
Bulletin describes 18 electric furnaces for research and small-scale production, with operating temperatures to 3000°F. *Harper Electric*

784. Furnaces
Metal Melting Newsletter on push-out furnace, a removable crucible furnace. *Inductotherm Corp.*

785. Furnaces
New Bulletin DL-58 on production tempering furnaces. *Ipsen*

786. Furnaces
Catalog on standard and special furnaces and ovens to 3000°F. *L & L Mfg.*

787. Furnaces
4-page reprint on high thermal head furnaces for continuous slab heating installation at Atlas Steels, Inc. Cross section view of radiamatic unit. *R-S Furnace Co.*

788. Furnaces
Bulletin SC-179 on gas-fired muffle furnace. Application in bright heat treatment and brazing. *Surface Combustion*

789. Furnaces
Folder describes complete set-up for heat treatment of small tools, including draw furnace, quench tank and high temperature furnace. *Waltz Furnace*

790. Furnaces, Heat Treating
12-page bulletin on conveyor furnace, radiant tube gas heated, oil or electrically heated. *Electric Furnace Co.*

791. Fused Silica
Folder on fused silica which is resistant to high temperatures, thermal shock, acids and has high electrical insulating value. *Amersil*

792. Gas Analysis
Bulletin No. 306 on gas analysis kits for on-the-job determinations of carbon dioxide or oxygen in flue gases, furnace atmospheres and other gas mixtures. *Burrell Corp.*

793. Gas Analysis
Bulletin 482 on gas chromatograph for analysis of gases and low-boiling liquids. How it works. *Harshaw Scientific*

794. Gas Welding
36-page Catalog 160 on applications of oxy-acetylene welding and cutting torches and accessories. *Modern Engineering*

795. Gold Plating
8-page paper gives bath composition, equipment and operating conditions, and metallurgical characteristics of 24K gold plate on various base metals. *Sel-Rex*

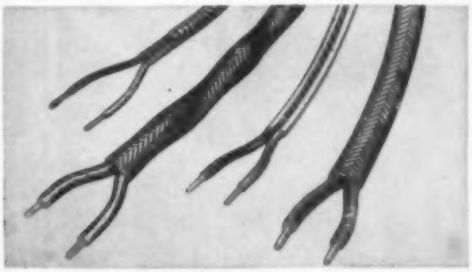
796. Gold Plating
Physical, thermal, chemical, electrical, diffusion and optical properties of electroplated gold. Uses. *Technic*

797. Graphite
20-page brochure on significance of graphite as electrodes, anodes, molds, and specialties in electrometallurgy and electrochemistry. *Great Lakes Carbon*

798. Graphite
Folder on graphite crucibles, funnels, and special preformed electrodes. High-purity powder. *United Carbon Products*

Thermocouple Wires

Quality • Variety • Delivery



Thermo Electric makes thermocouple and thermocouple extension wires for every possible use—actually over 1500 varieties. Just a few seconds with a T-E Wire Catalog will find the exact type you need. Solid and stranded conductors are available in all standard calibrations. The most modern types of insulations will meet all conditions of moisture, chemical action, abrasion and high temperature. Our own complete facilities for wire drawing, insulating and calibrating guarantee you unmatched quality. Prompt delivery on most types from our large stock.

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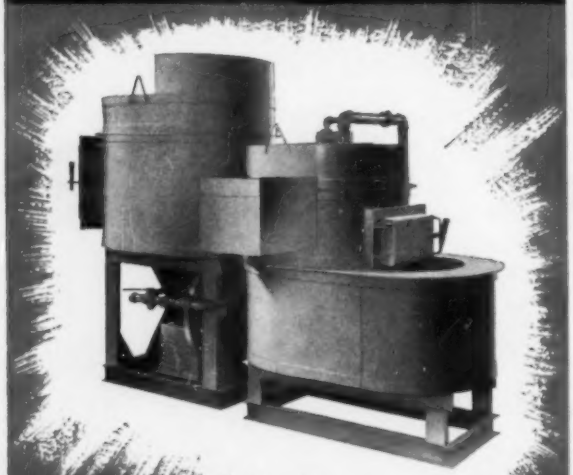

Stroman "DC" Cylinder Type Furnaces for Combination Melting and Holding Aluminum with CONTAINED COMBUSTION BURNERS

For Die Casting, Permanent Mold and Sand Casting Operations

"Versatility Plus" is the keynote of these newest Stroman Contained Combustion Furnaces. They are absolutely new in design for they incorporate Contained Combustion Burners which eliminate direct flame impingement on the metal. They also make for cooler working conditions because of less heat loss. They give greater fuel economy for less BTU input is required . . . Longest refractory life and least maintenance due to mild combustion conditions . . . Uniform heating condition and improved metal temperature control assure lowest metal losses.

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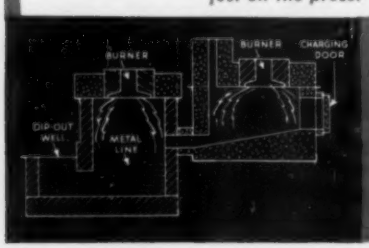
Roof of the furnaces are easily removed for furnace cleaning, relining, repair or burner service, as burner is mounted in the roof.

These Stroman "DC" Cylinder type furnaces are available in break down and holding combinations. However separate break down and holding units can be purchased. Break down units are often used to augment iron pot, electric and crucible furnace capacities.

Their flawless operation and ability to deliver years of trouble-free operation stamp them as a leading Stroman Aluminum production furnace. Investigate their cost cutting operation today.

Send for complete new catalogue No. 150 just off the press.



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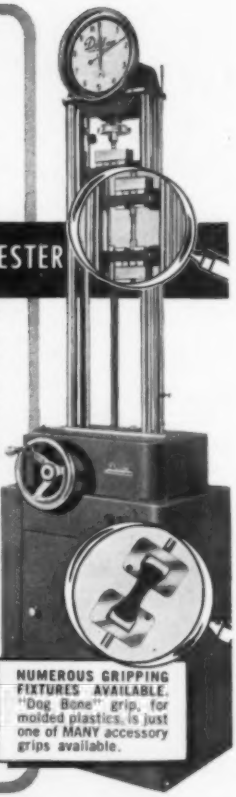

Designed for top accuracy at low cost, the DILLON Universal Tester is your wisest investment. Operates in tensile, compression, transverse or shear. Checks metal, plastics, wire, rubber, springs, etc. 7 interchangeable gauges. For materials up to 125,000 lbs. PSI tensile. Hand wheel operation or motorized. Equipped with max. indicator. Meets most all ASTM & Fed. specs. Handles round, flat or special shapes.

For low strength materials between 0 & 300 lbs. Model M (not shown) is available. Accurate to ½ of 1%. Has 5 scales.

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799. Gripping Fixtures
New bulletin on line of gripping fixtures for use in tensile, compression, transverse or shear to test any material. *W. C. Dillon*

800. Hard Surfacing
New 20-page Booklet No. HS-127 on hard surfacing electrodes and wires. Classifications, properties, applications of each. *McKay Co.*

801. Hardness Tester
20-page book on hardness testing by Rockwell method. *Clark Instrument*

802. Hardness Tester
Data on portable hardness tester with Rockwell and Brinell scales. *Mechanical Devices*

803. Hardness Tester
4-page bulletin on air-operated Brinell metal hardness tester. Operating principles, specifications. *Tinius Olsen*

804. Hardness Testers
New 20-page Catalog DH-325 on normal hardness testing. Applications, advantages, accessories. *Wilson Mechanical Instrument Div.*

805. Heat Exchanger
Bulletin 132 on sectional heat exchanger for use with quench bath, annealing furnace, wire drawing equipment and other industrial cooling functions. *Niagara Blower*

806. Heat-Resistant Castings
16-page bulletin on design, foundry practice and applications. *Electro-Alloys*

807. Heat Treat Pots
Catalog on pressed steel pots for lead, salt, cyanide, oil tempering and metal melting. *Eclipse Industrial Combustion*

808. Heat Treating
Data sheets on Aeroheat 300 and Aeroheat 1000 heat treating salts. Properties, uses, operating characteristics. *American Cyanamid*

809. Heat Treating
Monthly bulletin on used heat treating and plating equipment available for immediate delivery. *Metal Treating Equipment Exchange*

810. Heat Treating
12-page bulletin on heat treating equipment. Applications and special features of 19 different types of furnaces including shaker hearth, conveyor, high vacuum, elevator-type brazing. *Pacific Scientific*

811. Heat Treating
4-page bulletin on protective coatings on steel from heat treating method. Prevention of carburization or decarburization, selective carburization. *Park Chemical Co.*

812. Heat Treating Equipment
New 24-page Catalog 54 on light-weight processing and heat treating equipment. *Pressed Steel Co.*

813. Heat Treating Fixtures
32-page catalog G-10A lists process equipment, heavy welded fabrications, muffles, trays, fixtures for furnaces, heat-treating equipment, pickling equipment. *Rolock*

814. Heat Treating Fixtures
12-page bulletin on wire mesh baskets for heat treating and plating. *Wiretex*

815. Heat Treating Furnaces
Folder on industrial furnaces. Continuous designs. Insulation. *Pacific Industrial*

816. Heat Treating Guide
Chart guide constructed on slide rule principle for simplified hardening and drawing of tool steels. *Carpenter Steel*

817. Heat Treating Pots
Bulletin 110 gives data on sizes and

Will the ST-1 orbit the earth?

Gosh no, once you put it in your shop, it'll probably stay right there for years and years.

Well, is it ram-jet powered?

It's got a ram alright, but it's hydraulically powered. Works real smooth and easy.

Does that develop sufficient thrust?

Sure, you can test most any spotweld, strip, or wire within its 20,000 lb. capacity.

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What! We've got skilled people making the ST-1, it doesn't make hardly any noise.

Say, what kind of a missile is this?

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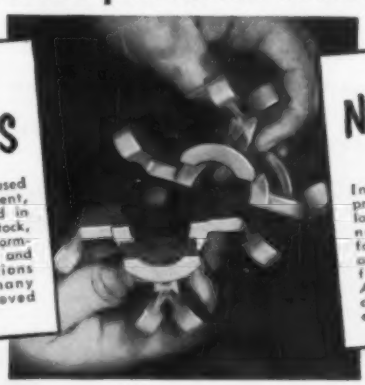
An intricate collar, used in sonar equipment, originally machined in 6 parts from bar stock, required blanking, forming, pre-machining and welding. Operations that created many problems and proved too expensive.



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Investment Casting produced the same collar in 2 parts. It eliminated all blanking, forming, pre-machining and welding. It simplified final assembly. And it materially reduced the cost of production.*

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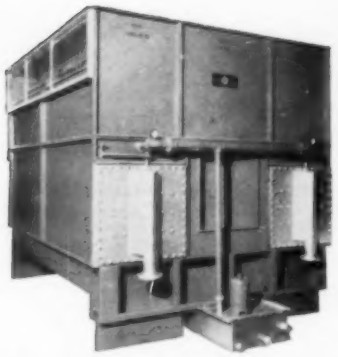

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shapes of cast nickel-chromium solution pots. *Fahralloy*

818. High-Alloy Castings

16-page bulletin, No. 3354-G, gives engineering data concerning castings used for resisting high temperatures, corrosion and abrasion. *Duraloy Co.*

819. High-Strength Steel

Data sheet and 16-page folder on Vasco-Jet 1000, 5% chromium air hardening steel. Mechanical properties, fatigue strength, heat treatment and surface properties. *Vanadium-Alloys Steel Co.*

820. High-Temperature Castings

16-page manual on heat and corrosion resisting castings. Principles of alloy composition, their properties and limitations, stabilizing influences and heat treatment. *Michigan Standard Alloy*

821. High-Temperature Alloy

New 28-page book on Hastelloy X, nickel base alloy. Property data, welding, machining, forging. *Haynes Stellite*

822. High-Temperature Lubrication

Bulletin 423 on colloidal graphite and molybdenum disulfide dispersions and their use for high-temperature lubrication. Case histories. *Acheson Colloids*

823. High-Temperature Steels

87-page book on factors affecting high-temperature properties. 45 pages of data on tensile, creep and rupture properties of 21 high-temperature steels. *U. S. Steel*

824. High-Tensile Steel

8-page bulletin on properties and composition of N-A-X high-tensile steel. Examples of resistance to impact, fatigue, abrasion and corrosion. *Great Lakes Steel*

825. Induction Heater

New 8-page bulletin on 60-cycle induction heater for aluminum, copper, brass and steel. Installations, billet heater selection chart for aluminum. *Magnethermic*

826. Induction Heating

Folder 15C8053C gives advantages of induction heating and specifications and dimensions of induction heater. *Allis-Chalmers*

827. Induction Heating

Folder on high-frequency induction heating includes diagrams of water-cooled, air-cooled and variable output work unit. *Cincinnati Milling Machine*

828. Induction Heating

High Frequency Review contains article on high temperature fatigue tests using induction heating. *Lepel High Frequency Laboratories*

829. Induction Heating

8-page catalog section 22C on induction heating for forming and forging. Advantages of induction heat. *Ohio Crankshaft*

830. Industrial Equipment

12-page catalog on finishing systems, cleaning, pickling, rustproofing equipment, ovens, conveying equipment. *R. C. Mahon Co.*

831. Inspection

New Bulletin 90 on nondestructive testing of ferromagnetic wire rope. Equipment and how it is used. *Magnetic Analysis*

832. Inspection

16-page catalog on illuminated Borescopes for industrial inspection of deep recessed areas. *National Electric Instrument Div.*

833. Instruments

New 60-page Catalog 500 on supplies and accessories for instrument users. *Foxboro*

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834. Insulators
Bulletin P1-55 on insulators and insulating tubing. *McDanel Refractory Porcelain*

835. Laboratory Equipment
12-page catalog on high-frequency induction combustion units and accessories for carbon, sulphur and hydrogen analysis. *Lindberg Engineering*

836. Laboratory Equipment
New bulletin on cutting test specimens describes methods for different types of metals. Price list. *Sieburg Industries*

837. Lithium
New 24-page booklet on lithium, cesium and rubidium. Principal uses. Charts and tables. *Montgary Explorations, Ltd.*

838. Lubricant
Bulletin 103A on fringe area lubrication with molybdenum disulfide lubricants for extreme bearing pressures and all temperatures. *Alpha Molykote*

839. Lubricant
New 4-page Data Sheet No. 2049 on solid film lubricant. *Electrofilm*

840. Lubricant
8-page booklet, "Biggest Ounce of Protection", tells of lubrication with colloidal graphite products. *Grafo Colloids*

841. Machining Titanium
8-page bulletin on turning, milling, drilling, tapping, grinding. Recommendations for each. Typical properties of titanium. *Mallory-Sharon Metals*

842. Manganese
9-page article on electromanganese. Manufacturing procedures, product characteristics, uses. In Foote Prints, V. 28, No. 2. *Foote Mineral Co.*

843. Marking Machines
Data on various types of marking machines from bench mounted machines for light duty marking to machines capable of marking at up to 6 tons table pressure. *Jas. H. Matthews & Co.*

844. Melting
New Bulletin 14-B on high frequency furnaces for melting ferrous and nonferrous alloys. High temperature applications up to 3600°C. *Ajax Electrothermic*

845. Melting Aluminum
Bulletin 310 on furnaces for melting aluminum. *Lindberg Engineering Co.*

846. Melting Furnace
New Bulletin R-58 on coreless induction melting furnace for ferrous and nonferrous metals. Technical data, applications, advantages. *Ajax Engineering*

847. Melting Furnaces
New Bulletin No. 85 on melting furnaces for brass, bronze, aluminum and other nonferrous metals. Both mechanical and hydraulic methods. *Stroman Furnace & Engineering Co.*

848. Metal Sorting
Data on nondestructive sorting tool for raw, semi-finished or finished parts. *J. W. Dice*

849. Microscopes
Catalog on metallograph and several models of microscopes. *United Scientific*

850. Mixers
New Bulletin 581 on high speed, vertical and batch-type mixers. *Conn & Co.*

851. Mixers
20-page booklet B-103 on fixed mounting propeller-type fluid mixers. Mixing capacities, standard sizes and speeds. *Mixing Equipment*

852. Molybdenum
8-page reprint on arc-cast molybdenum describes machining procedures, tools and

(*Continued on page* 48-A)

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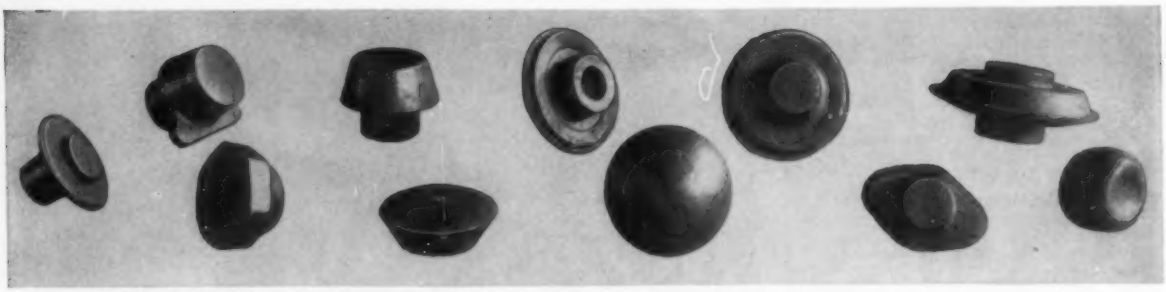

Typical Shapes Produced by ACME Single Blow Forging Machines

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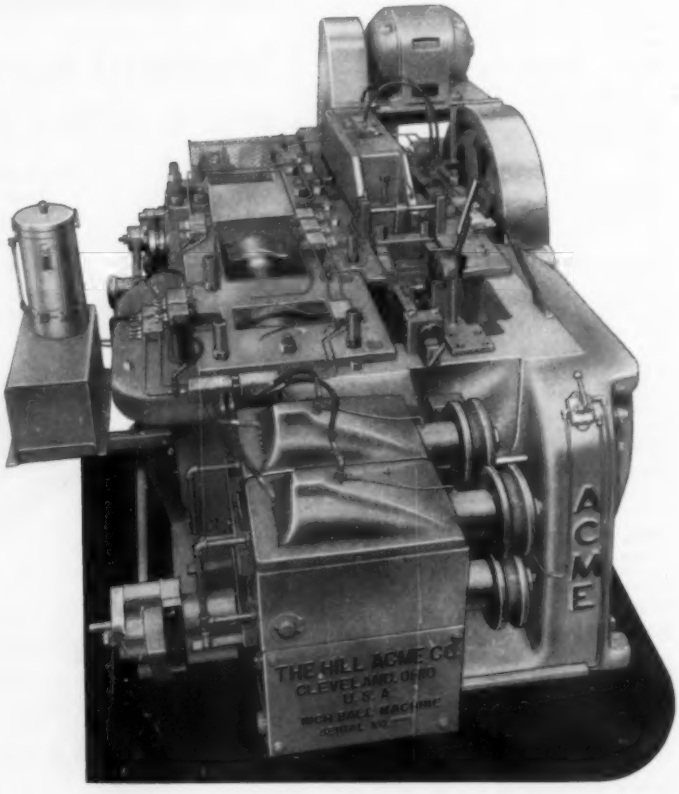

One man operating this ACME single blow solid die forging machine is producing 135 one inch hard steel balls per minute from 11/16" stock. Automatic feed rolls carry bar stock at proper speed for maximum efficient operation. Adequate safety devices prevent jamming of the die.

ACME solid die forging machines are rated according to the size ball they will forge. Machines are built from 1" to 5" capacity.

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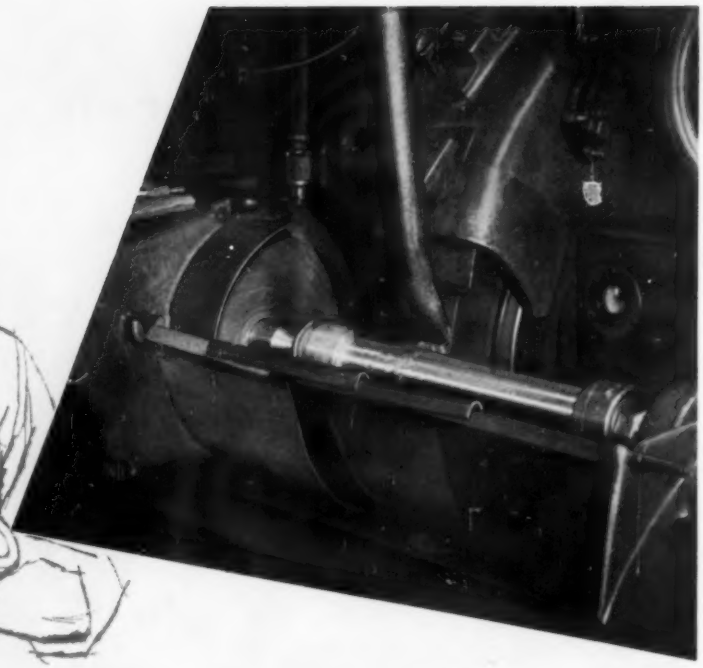

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(Continued from page 45)

equipment. How to machine a turbine wheel. *Climax Molybdenum Div.*

853. Nickel Alloys
38-page catalog on Monel, Inconel, nickel and nickel clad copper. Includes properties, applications and technical data. *Riverside-Alloy Metal*

854. Nickel Chromium Steels
8-page bulletin with 28 charts on composition, heat treatment, transformation characteristics and mechanical properties of the standard nickel-chromium steels. *International Nickel*

855. Nondestructive Inspection
8-page bulletin on use of ultrasonic Reflectoscope describes principles of ultrasonic inspection. *Sperry Products*

856. Nondestructive Testing
8-page bulletin on equipment for nondestructive testing of bars, rods, tubing. *Magnetic Analysis*

857. Nonferrous Wire
Folder gives wire gage and footage chart and data on beryllium copper, phosphor bronze, nickel, silver, brass and aluminum wire. *Little Falls Alloys*

858. Optical Parts
New 16-page Catalog L-117 on full line of optical parts. 28 tables. *Bausch & Lomb*

859. Ovens
New Bulletin No. 5720 on mechanical recirculating utility ovens with automatic temperature control. *Blue M Electric*

860. Ovens
New Bulletin 4-257 on gas, oil and electric ovens. Load carrying door, electric drawer and walk-in type ovens. *Grieve-Hendry*

861. Phosphating
Folder on phosphating and metal protective coating materials. Purpose and make-up of each type of coating. *Turco*

862. Phosphor Bronze
Facilities for rolling, cleaning, welding, trimming and treating phosphor bronze. *Rolling Mill Div., Miller Co.*

863. Photographic Films
Catalog of motion picture, radiographic and industrial films, photographic papers and luminescent chemical products. *DuPont*

864. Pickling Baskets
Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

865. Plating
8-page brochure on test equipment for plating baths. Controls, anodes, cathodes, agitators, rectifiers. *R. O. Hull*

866. Plating
Data and specification sheet covering tin plating a wide range of nonferrous thin strip metals. *Somers Brass Co.*

867. Portable Recorder
Bulletin 60-100 on instrument for recording any measurement that can be converted to a change in resistance of d. c. millivoltage. *Thermo Electric*

868. Potentiometer
Bulletin F-7955-1 on multipoint potentiometer recorder. Specifications, ranges, models. *Wheelco*

869. Powder Metallurgy
12-page bulletin B-101 on furnaces for sintering powder metal products and reduction of metallic oxides. *Drever*

870. Powder Metallurgy
Technical literature on high-density sintered metal parts. *Supermet Div.*

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New 12-page Bulletin No. 2 on iron powders. Properties of Plast/Iron, Plast/-Steel, Plast/Nickel, Plast/Manganese and Plast/Silicon. *Plastic Metals Div.*

872. Precision Casting
12-page book tells when to use precision castings, tolerances, how castings are made. *Alexander Saunders*

873. Press
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877. Pyrometers
Data sheet 1E-1 on high-resistance indicating pyrometers. Special thermocouples for surface measurement, molten nonferrous metals, general immersion. *West Instrument*

878. Quenching Oil
10-page book on new oils for the quenching process gives results on hot wire quench test and in plant operation. *Sinclair Refining Co.*

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24-page booklet describes radioactive chemicals and their uses. Lists those available. *Baker & Adamson*

880. Radiography
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54 references to applications of rare earth metals in aluminum, cobalt, magnesium, nickel and other nonferrous alloys. *New Process Metals, Inc.*

883. Rare Earths
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884. Recirculating Furnace
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8-page catalog of super refractory shapes, tubes, insulators for use to 3542° F. *Morganite, Inc.*

886. Refractories
New bulletin, 1922, on two high temperature Alundum castable refractories. Properties and how to use them. *Norton*

887. Refractory Metals
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888. Resistance Alloys
New 20-page booklet M-57A on 80-20 nickel-chromium alloy. Heating element design data. Metallurgical factors which affect high-temperature operations. *Hoskins Mfg.*

889. Rolling Mills
New Catalog FRM-58 on mills for laboratory and development, wire flattening. Accessories. *Fenn Mfg.*

890. Rust Prevention
Bulletin No. 51 on anionic surface active agent for oil-soluble rust and corrosion inhibitors, emulsifying, wetting and dispersing agents. *Sun Oil*

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Bulletin on nonflammable rust preventive compound which is water soluble, nontoxic. *Production Specialties*

892. Salt Bath Furnaces
Data on salt bath furnaces for batch and conveyorized work. *Upton*

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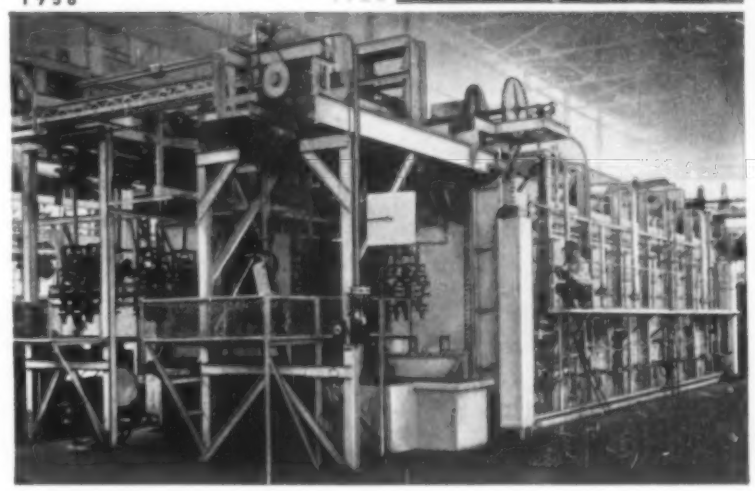

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48-A

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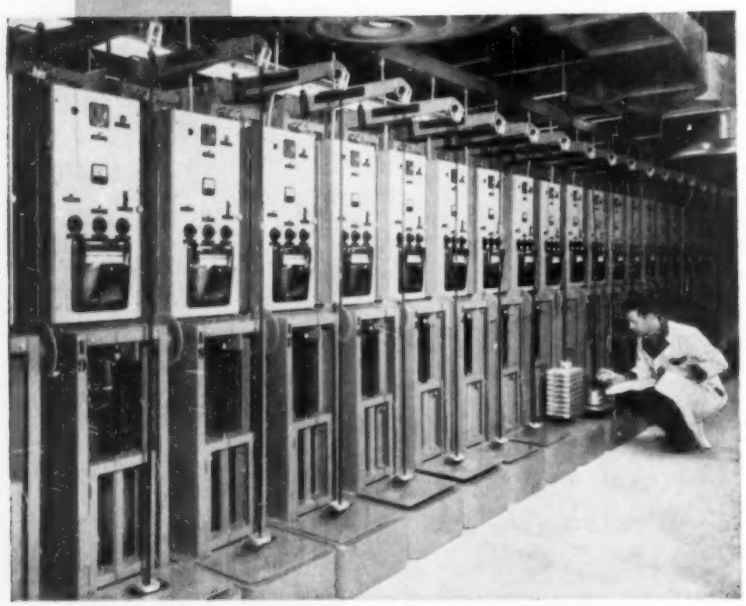

Part of the 30 Arcweld Manufacturing Co. creep-test furnaces equipped with Wheelco 400 Series Capacitrols

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48-B

893. Saws
Catalog C-55 describes 35 models of metal-cutting saws. *Armstrong-Blum*

894. Shotblasting
16-page "Primer on the Use of Shot and Grit". Problems of blast cleaning operations. *National Metal Abrasive*

895. Silver Brazing
48-page manual on all aspects of silver brazing applications and problems. *American Platinum & Silver Div.*

896. Sintered Carbides
24-page booklet on the characteristics of the various grades, for research and design engineers. *Kennametal*

897. Slitting
76-page handbook on multiple rotary slitting lines. Design, selection and operation of slitters. Specifications and capacity tables. *Yoder Co.*

898. Sodium
28-page booklet on using sodium in dispersed form tells how dispersions are prepared and handled, and their advantages. *Ethyl Corp.*

899. Spectrometer
8-page Bulletin 44 on direct reading spectrometers. Operation and construction. *Baird Atomic*

900. Spray Painting
New 6-page booklet on airless spraying. How it works, advantages. *Nordson*

901. Spring Steels
48-page booklet on selection of spring steel. How it is made, hardness values, physical property data. *Wallace Barnes Steel Div., Associated Spring Corp.*

902. Stainless Steel
Booklet on 430 stainless. Properties, fabrication. *Sharon Steel*

903. Stainless Steel
28-page book on Type 430 nickel-free chromium stainless. Properties, surface characteristics, fabrication, applications. *Washington Steel Corp.*

904. Stainless Tubing
12-page brochure on stainless steel heat exchanger and condenser tubes. Manufacture, chemical composition and analysis. *Republic Steel*

905. Stampings
New brochure on stamping and forming of precision small parts. Methods used, equipment for manufacturing, inspecting and testing. *Be Cu Mfg. Co., Inc.*

906. Steel
New 6-page bulletin on aluminized steel Type 1. Advantages. *Armco*

907. Steel 52100
Stock list on 52100 tubing, bars and ring forgings. *Peterson Steels*

908. Steel Bars
12-page paper on effect of copper, abnormally heavy drafts, furnace treatment and die practice on Stressproof steel bars. Bibliography. *LaSalle Steel*

909. Steel Castings
Folder contains chart of grades, analyses, properties, comparable specifications for usual casting steels. *Induction Steel Casting Co.*

910. Steel Castings
Two bulletins on medium and medium high carbon steel casting specifications. Allied specifications, analysis, properties, hardenability. *Unitcast*

911. Steel Tubing
12-page booklet on uses of seamless and electric resistance welded steel tubing in materials handling equipment. *Ohio Seamless Tube Div.*

912. Test Equipment
Catalog R-36A on complete line of testing equipment, including all industrial electronic and electrical equipment. *Weston Electrical Instrument*

913. Testing Equipment
80-page illustrated catalog lists over 130 testing and measuring tools for laboratory and production-line use. *General Electric*

914. Testing Machines
12-page catalog on ten testers including hardness, ductility, tensile, compression and transverse strength. *Detroit Testing Machine*

915. Thermocouple Wire
New Bulletin 1200 on thermocouple extension wire. Application data, sizes and types. *Claud S. Gordon*

916. Titanium Powders
Data on high purity and commercial titanium powders. *Hawkridge Metals*

917. Tool Steel
Fourth edition of the 204-page handbook. Types, properties and applications of tool steels. Selection, tool steel products, working tool and high speed steels. *Allegheny Ludlum*

918. Tool Steel
New 10-page Booklet 458 on general purpose tool steel. Analysis, uses, characteristics, wear resistance. *Bethlehem*

919. Tool Steel
44-page stock list is indexed and includes sizes, weights, and analyses. Decimal conversion and hardness conversion tables. *Uddeholm*

920. Tool Steels Brand Chart
Wall chart listing over 300 popular tool steels by types. *Vulcan Crucible Steel*

921. Tubing
New Data Card TDC-115 D on dimensional tolerances, both cold-drawn and hot-finished, of round, seamless carbon and alloy steel tubing. *Tubular Products Div., Babcock & Wilcox*

922. Tubing
New 10-page Bulletin No. 70 on superalloy tubing. Chemical composition, physical and mechanical properties. 8 tables, 8 graphs. *Superior Tube*

923. Tungsten
12-page booklet on tungsten coil products for electronic and lighting applications. *Sylvania Electric Products Inc.*

924. Ultra Strength Steel
Results of three year research and test program evaluating properties of Type 4340 steel for aircraft structures. *International Nickel*

925. Vacuum Furnaces
Articles on commercial vacuum furnaces for metals and alloys and some aspects of vacuum melted metals. *National Research*

926. Vacuum Melting
8-page bulletin on production and testing equipment for vacuum melting. Advantage. *Utica Metals Div.*

927. Vanadium in Steel
189-page book on properties of ferrous alloys containing vanadium and their applications. *Vanadium Corp.*

928. Welding
New 22-page booklet on welding positioners. Case histories. *Harnischfeger*

929. Wrought Iron
New 16-page booklet, "The ABC's of Wrought Iron". What it is, how it is made, fabrication, corrosion resistance, applications. *A. M. Byers Co.*

930. X-Ray
12-page bulletin on gamma radiography tells how to select the source, equipment, techniques and fundamentals of gamma radiation. *Picker X-Ray*

931. X-Ray Diffraction
4-page folder 7A-3690 on X-ray diffraction. What it is, Bragg's law, equipment, applications. *General Electric, X-Ray Dept.*

932. X-Ray Diffraction
New 14-page booklet "Questions and Answers" on X-ray diffraction, diffractometry and spectrography. *Philips Electronics, Inc.*

April, 1958

714	734	754	774	794	814	834	854	874	894	914	934
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716	736	756	776	796	816	836	856	876	896	916	936
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718	738	758	778	798	818	838	858	878	898	918	938
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720	740	760	780	800	820	840	860	880	900	920	940
721	741	761	781	801	821	841	861	881	901	921	941
722	742	762	782	802	822	842	862	882	902	922	942
723	743	763	783	803	823	843	863	883	903	923	943
724	744	764	784	804	824	844	864	884	904	924	944
725	745	765	785	805	825	845	865	885	905	925	
726	746	766	786	806	826	846	866	886	906	926	
727	747	767	787	807	827	847	867	887	907	927	
728	748	768	788	808	828	848	868	888	908	928	
729	749	769	789	809	829	849	869	889	909	929	
730	750	770	790	810	830	850	870	890	910	930	
731	751	771	791	811	831	851	871	891	911	931	
732	752	772	792	812	832	852	872	892	912	932	
733	753	773	793	813	833	853	873	893	913	933	

METAL PROGRESS,

7301 Euclid Avenue, Cleveland 3, Ohio

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Company

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City and State

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These OTTAWA 60 DIES PAYOFF BIG IN 3 WAYS

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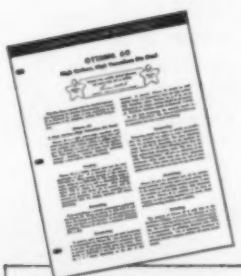

Write for BLUE SHEET on OTTAWA 60

This concise four-page folder gives all needed handling and shop treatment details on Ottawa 60. Included is certified laboratory information on physical characteristics, and complete data on forging, annealing, hardening, tempering, etc. *Ask for your copy.*

ADDRESS DEPT. MP-4

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One way to increase profits is to reduce finishing costs. That's what a fabricator of hearing aid cases accomplished when he switched from regular die steel to A-L's air hardening Ottawa 60 high carbon-high vanadium grade.

Ottawa 60 dies produced stainless steel cases which were free from galling and scoring—were nearly perfect as they came out of the dies. Less than half the previous buffing time was needed to bring them to the required high finish. Rejects—which ran about 20 percent before the use of Ottawa 60—were reduced almost to the point of elimination. Also, the new Ottawa 60 dies required stoning and regrinding only a quarter as often as the standard tool steel dies they replaced.

This same manufacturer has passed along significant savings to other customers through the use of Ottawa 60. By practically eliminating rejects due to corner cracking and scoring, customers receive better stamped parts at lower per-piece cost.

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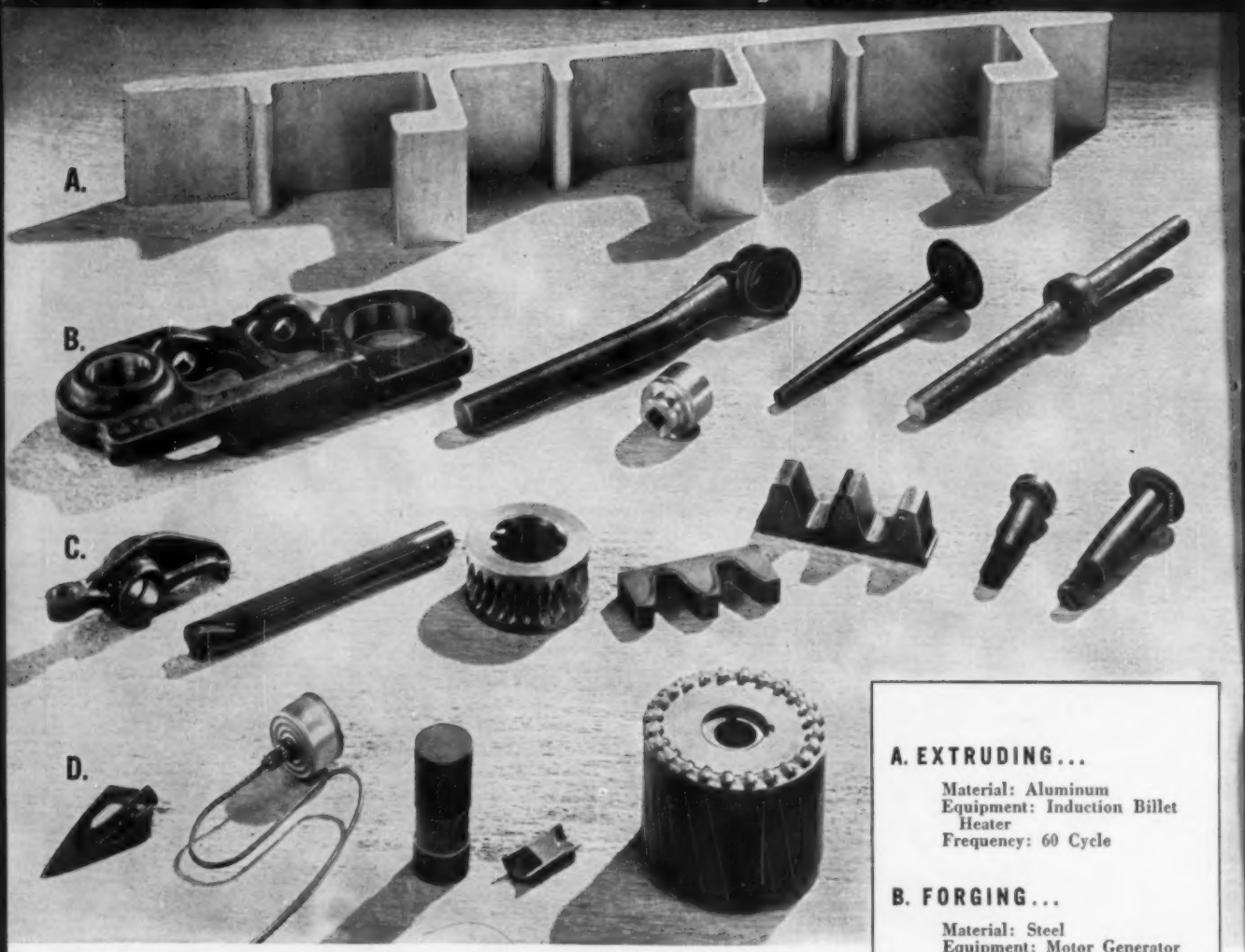
METAL TREATING WITH MAGNETHERMIC INDUCTION HEATING



A. EXTRUDING...

Material: Aluminum
Equipment: Induction Billet Heater
Frequency: 60 Cycle

B. FORGING...

Material: Steel
Equipment: Motor Generator
Frequency: 3,000 and 10,000 Cycles per Second

C. HARDENING...

Selective and Surface

Material: Steel
Equipment: Motor Generator, Electronic Induction Heater
Frequency: 10,000 Cycles per Second; 450,000 Cycles per Second

D. BRAZING...

Material: Copper, Brass, Steel
Equipment: Motor Generator, Electronic Induction Heater
Frequency: 10,000 Cycles per Second; 450,000 Cycles per Second

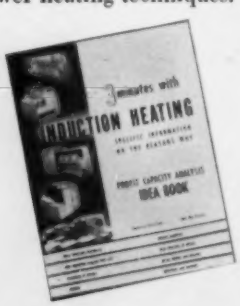
ten years ago . . .

INDUCTION HEATING never entered this picture

Parts like these were heated by costly, conventional methods. The amazing potentials of induction heating had not yet been realized.

Today, MAGNETHERMIC induction heat processes such parts in seconds, with complete production-line automation. Cost-conscious production men everywhere call on MAGNETHERMIC for important cost reductions in all types of metal treating . . . surface hardening, tempering, annealing, stress relieving, and billet heating, to name a few.

Tomorrow, new products, many unheard of today, will require still newer heating techniques. MAGNETHERMIC engineers, creative leaders in the field, are ready with the newest concepts in induction heating to help you reach new production horizons.



This "A-B-C's of Induction Heating" booklet will be most helpful. Write today for your free copy. Send a part or detail prints for authoritative analysis.

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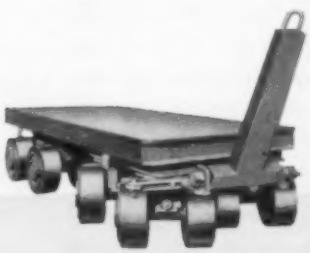
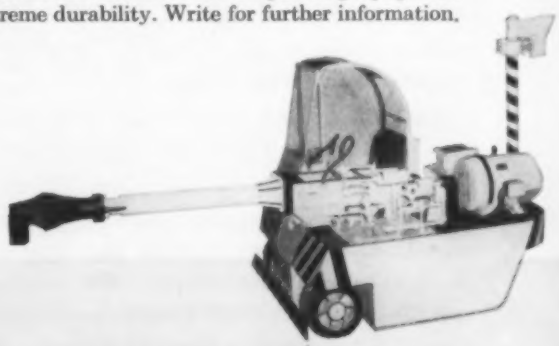
Easy answer to heavy forging needs

The free-moving Salem-Brosius rubber-tired manipulator adds speed, safety and economy to open-die forging. At hammer or press it raises, lowers, tilts, rotates or laterally moves the hot stock, satisfying forge manipulating requirements. Also, it can charge or draw forge shop furnaces, operating with the facility of a fork-lift truck in hot or cold stock handling. The Salem-Brosius Manipulator saves floor space. It travels to furnaces and presses or hammers without freezing floor space with tracks or overhead areas with craneways.

This ruggedly-built machine meets the trend of industry toward hammer and press forging of high alloy, stainless and tool steels, and the many new extremely hard refractory-type alloys. The forging of these metals necessitates manipulating equipment of extreme durability. Write for further information.



Two other prominent members of the Salem-Brosius family of materials handling equipment are heavy-duty in-plant trailers (left) and the exclusive rubber-tired type furnace chargers shown at the right. Ask about them when you inquire about the manipulator.



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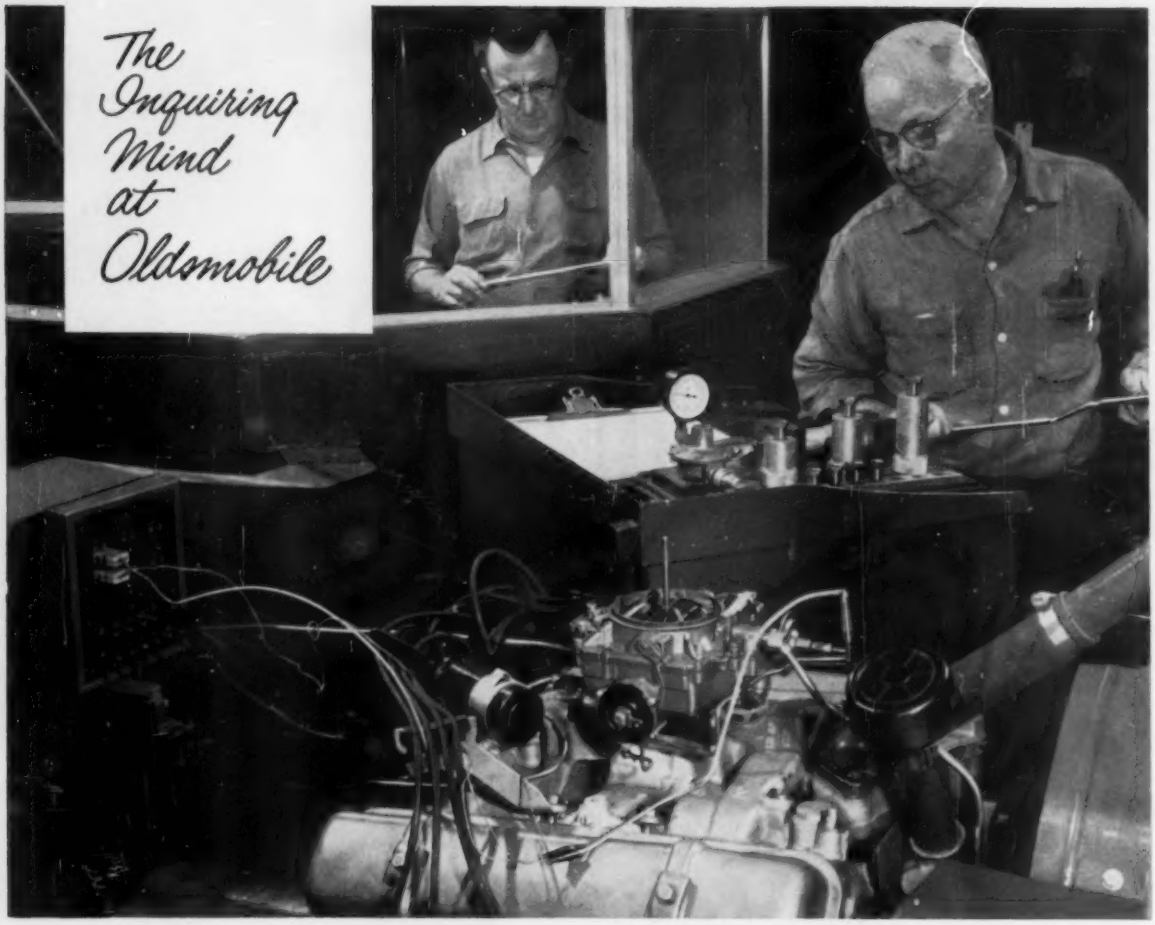
SPECIAL MECHANICAL EQUIPMENT • INDUSTRIAL HEATING FURNACES • MATERIALS HANDLING EQUIPMENT

The Inquiring Mind at Oldsmobile



no. 2 OF A SERIES

IT "WORKS" WHILE IT WHISTLES

Advanced sonic testing techniques are used to make precision measurements that determine an engine's compression ratio.

To Olds engineers, compression ratio is a direct measure of the engine's thermodynamic efficiency; the higher the compression ratio, the more energy utilized from the fuel. But with higher compression ratios, engineers needed to know whether cylinder heads and combustion chambers were accurate during initial engine development. To meet this challenge, Oldsmobile engineers and General Motors Research developed a simple, yet extremely accurate measuring device commonly called the "whistle checker".

Based on the principle of resonance, the known volume of air in the "whistle checker" is placed in resonance with the unknown volume of air in the combustion chamber. A reading of the micrometer adjusting screw of the "whistle checker" is easily translated into cubic centimeters and is accurate to .2 cc. What is just as important, this instrument can tell if there is any loss of compression due to leakage past the piston rings.

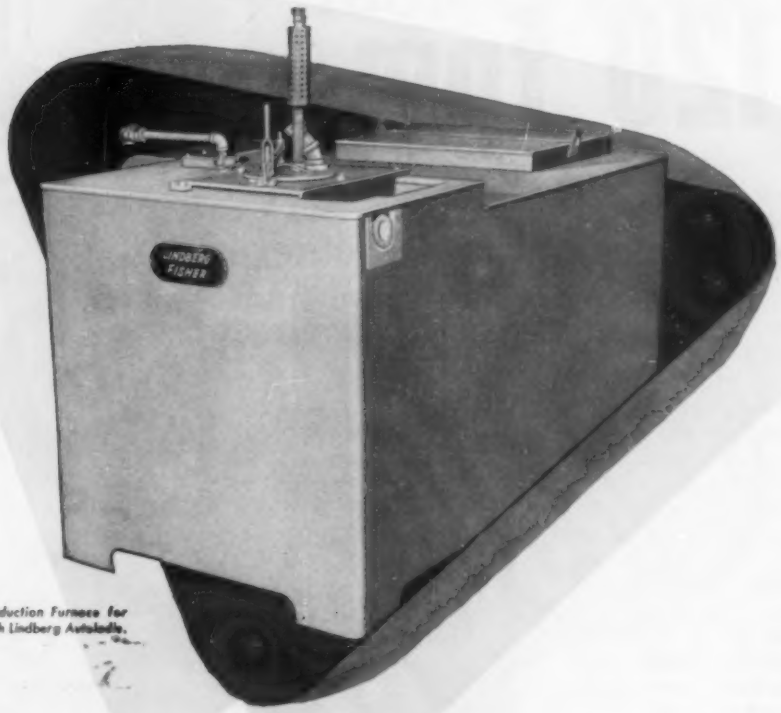
In many ways and in many directions the Inquiring Mind at Oldsmobile is constantly probing, constantly seeking new and better ways to build the finest automobiles in the industry. Try a '58 Oldsmobile on the road. You'll discover the difference for yourself.

OLDSMOBILE DIVISION, GENERAL MOTORS CORP.

OLDSMOBILE

Pioneer in Progressive Engineering ...Famous for Quality Manufacturing

Here's the ideal combination for casting aluminum automatically



Lindberg-Fisher two-chamber Induction Furnace for melting and holding equipped with Lindberg Autoladle.

Do you die-cast aluminum? Then take Lindberg's famous two-chamber induction melting and holding furnace, add "Little Joe" Lindberg's new automatic pump, and you'll have the most efficient automatic combination anywhere. The Lindberg-Fisher two-chamber furnace *melts* in one chamber, *holds* metal at precisely the right temperature in the other chamber, and "Little Joe" automatically delivers exactly the right size shot to the casting machine. With this combination all handling of molten metal is eliminated, perfect control of metal temperatures and shot size is maintained, and all automatically. For safer, more economical, more precise handling of aluminum or any non-ferrous metals or alloys better see Lindberg. Just get in touch with the Lindberg plant or the Lindberg Field Representative in your locality, or write Lindberg-Fisher Division, Lindberg Engineering Company, 2448 West Hubbard St., Chicago 12, Illinois. Los Angeles Plant: 11937 S. Regentview Ave., at Downey, California.

LINDBERG heat for industry

BRIDGEPORT BRASS COMPANY

Welds Aluminum Tubing at speeds up to

120 fpm

with an

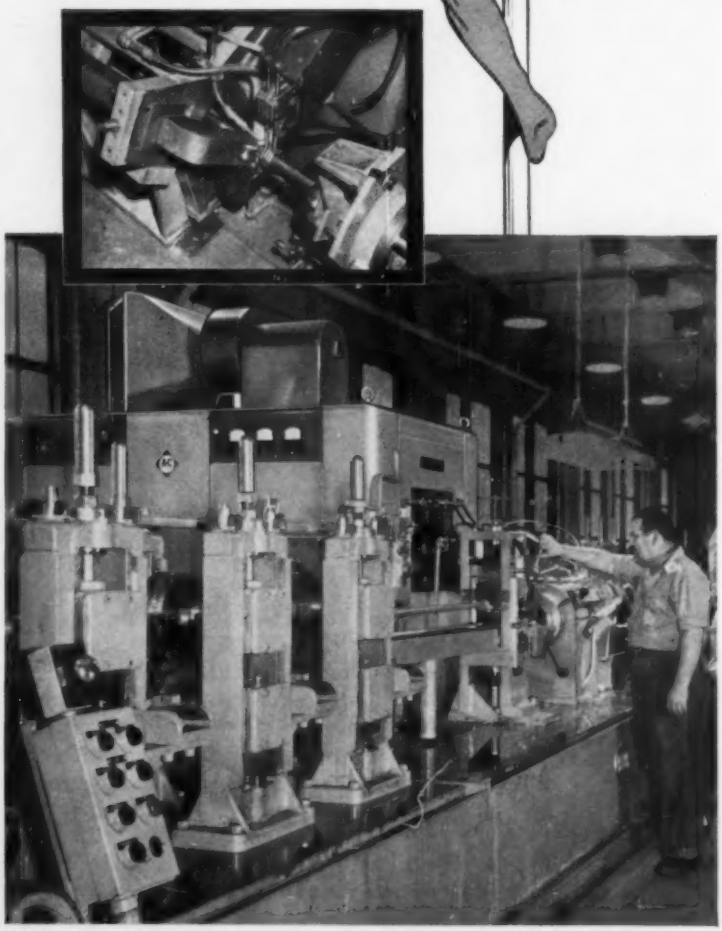
Allis-Chalmers Induction Heater

MR. HI FREQUENCY and the Allis-Chalmers induction heater solved an important production problem and gave Bridgeport Brass tremendous welding speed. Because aluminum has an abrupt melting point and a tendency to buckle, conventional arc welding yielded but a few feet per minute. By *confining* heat to a thin surface layer at the contacting edges of the formed tubing, Allis-Chalmers induction heating produced amazingly good results where previous methods failed.

Why Allis-Chalmers

Allis-Chalmers enhances induction heating's inherent speed with properly designed work handling equipment. An automatic timer and output controls, standard on Allis-Chalmers units, promote precision operation. Extensive laboratory facilities, unparalleled application experience, factory supervised installation and service assure complete dependability.

If you braze, solder, harden, anneal or heat for forging or melting, it will pay you to get all the facts on Allis-Chalmers induction heaters. See your nearby Allis-Chalmers representative or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wis.



Heart of Bridgeport's integrated mill is a 50-kw Allis-Chalmers induction heater. Coil is interchangeable to accommodate various tube sizes.

A-C ALLIS-CHALMERS

A-5456

ALLIS-CHALMERS

When aluminum needs heat treating it's time to look to LINDBERG

Lindberg Cyclone batch type furnace for heat treating aluminum castings.

When your use of aluminum makes it essential to apply heat for annealing or stress relief Lindberg can come up with the right equipment to do the job. Whatever the requirement our long experience in the application of heat to all types of metal can provide you with just the right furnace to fill your specific need. Maybe the batch type furnace shown here is what you need, or a big bottom quench for treating large aluminum sheets. No matter, Lindberg's staff of engineers, metallurgists and research technicians will face up to your problem. They'll help you find the answer, too, with the right type of equipment to treat aluminum or aluminum alloys to exact requirements of your product. Just get in touch with the Lindberg plant or the Lindberg Field Representative in your locality. Lindberg Engineering Company, 2448 West Hubbard St., Chicago 12, Illinois. Los Angeles Plant: 11937 S. Regentview Ave., at Downey, California.

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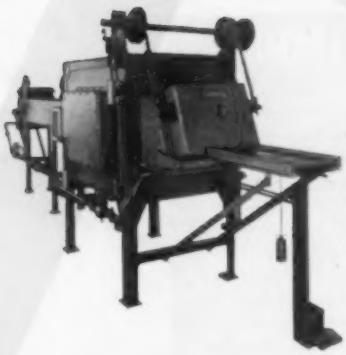
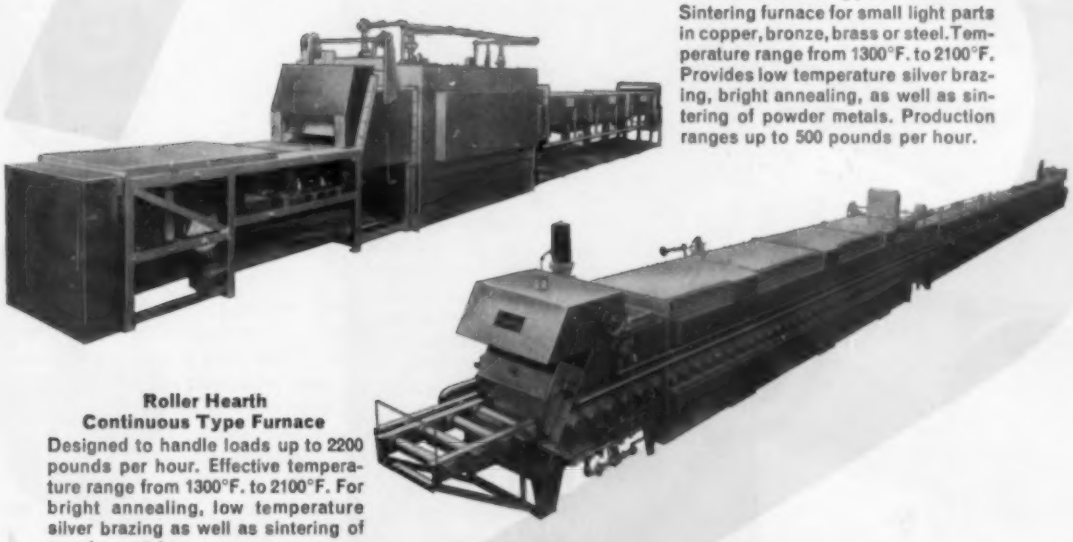
Look to Lindberg for sintering furnaces



Hand Pusher Batch Type Furnace
For small production lots and experimental sintering. An all-purpose unit for operation from 1300° F. to 2500° F. Made in various sizes for sintering from 25 to 300 pounds per hour.

Mesh Belt Continuous Type Furnace
Sintering furnace for small light parts in copper, bronze, brass or steel. Temperature range from 1300°F. to 2100°F. Provides low temperature silver brazing, bright annealing, as well as sintering of powder metals. Production ranges up to 500 pounds per hour.



Roller Hearth Continuous Type Furnace
Designed to handle loads up to 2200 pounds per hour. Effective temperature range from 1300°F. to 2100°F. For bright annealing, low temperature silver brazing as well as sintering of powder metals.

Lindberg atmosphere generators provide the proper atmospheres recommended for use with Lindberg Sintering Furnaces. These are: 1. HYEX Generator... approximately 4% carbon dioxide—18% hydrogen—12% carbon monoxide and 66% nitrogen. 2. HYEN Generator... neutral atmosphere approximately 21% carbon monoxide—40% hydrogen—38% nitrogen and 1% methane. 3. HYAM Generator... composed of approximately 75% hydrogen and 25% nitrogen.

For sintering furnaces, just as in all types of industrial heating equipment, you can depend on Lindberg's ability to supply exactly the right equipment for your needs. Just get in touch with your nearest Lindberg Field Representative, or write Lindberg Engineering Company, 2448 West Hubbard Street, Chicago 12, Illinois. Los Angeles Plant: 11937 South Regentview Avenue, at Downey, California.

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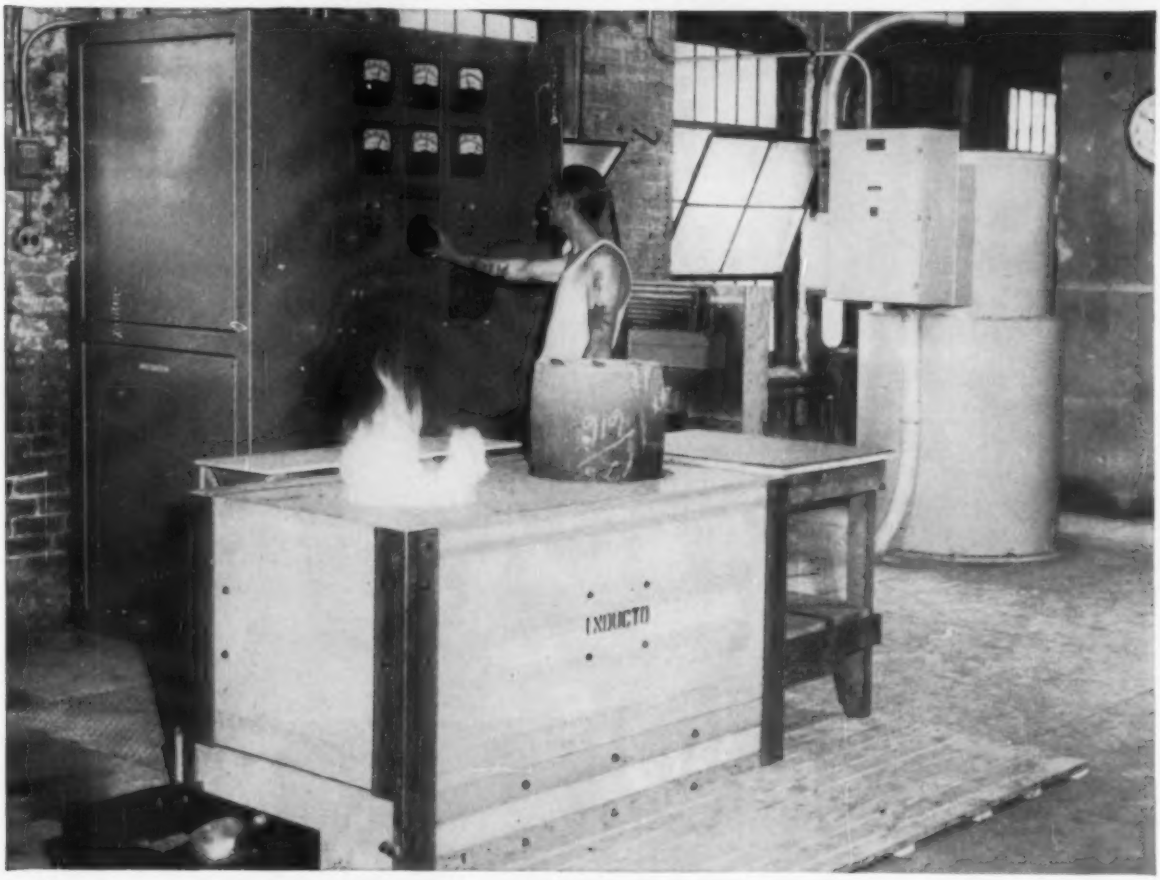

PHOTO COURTESY OF BUSHINGS, INC., PHILA. 32, PA.

The Foundry and the Feather Duster

Shortly after Bushings Incorporated, a Philadelphia manufacturer of cast bronze bushings and bearings, replaced four oil-fired furnaces with an INDUCTO Push-Out induction furnace, the management received a strange request . . . the foundrymen wanted a feather duster. They liked the INDUCTO furnace and control so much, and were so pleased with the cooler and cleaner foundry, that they wanted a feather duster to keep the equipment clean.

And the management was pleased too! For in addition to happier and more productive employees, they gained other benefits. The higher melting speeds and precision control of the INDUCTO Push-Out furnace helped reduce metal losses. In addition, it became possible to reclaim metal from melts and machining. Production time was saved in the handling of crucibles and the transferring of melts. In fact, the one INDUCTO Push-Out furnace provided as many melts in six hours as the four oil-fired furnaces did in eight.

Why not learn for yourself how INDUCTO furnaces and precision control can help modernize your foundry and save production dollars? Write today for more complete details.

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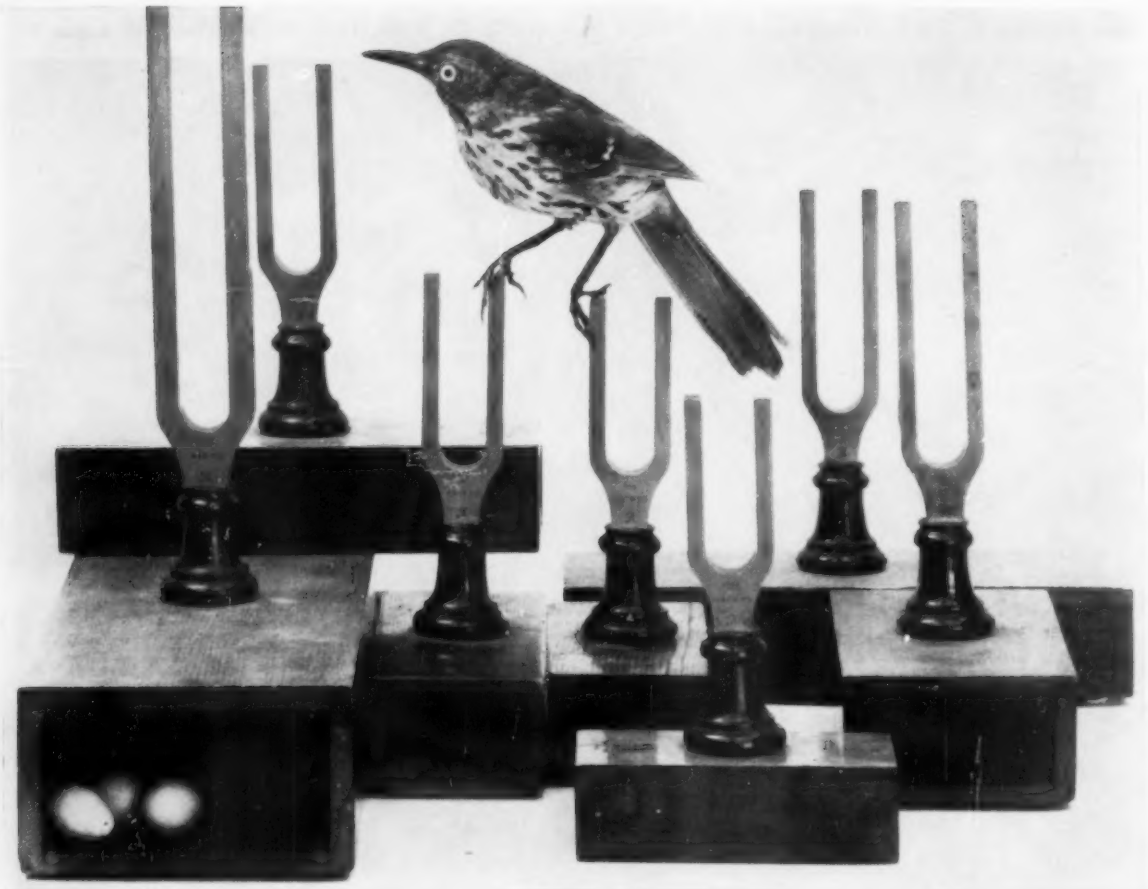

The tender touch of evaluation

Once, the testing and evaluation of industrial materials and products was anything but birdlike. To see if something worked, you often had to tear it apart.

Today, industry employs the tender miracle of *non-destructive testing:* radiography.

When it comes to testing industrial materials, more and more people are specifying Ansco X-ray Films—first films ever tailored especially for the needs of industry.

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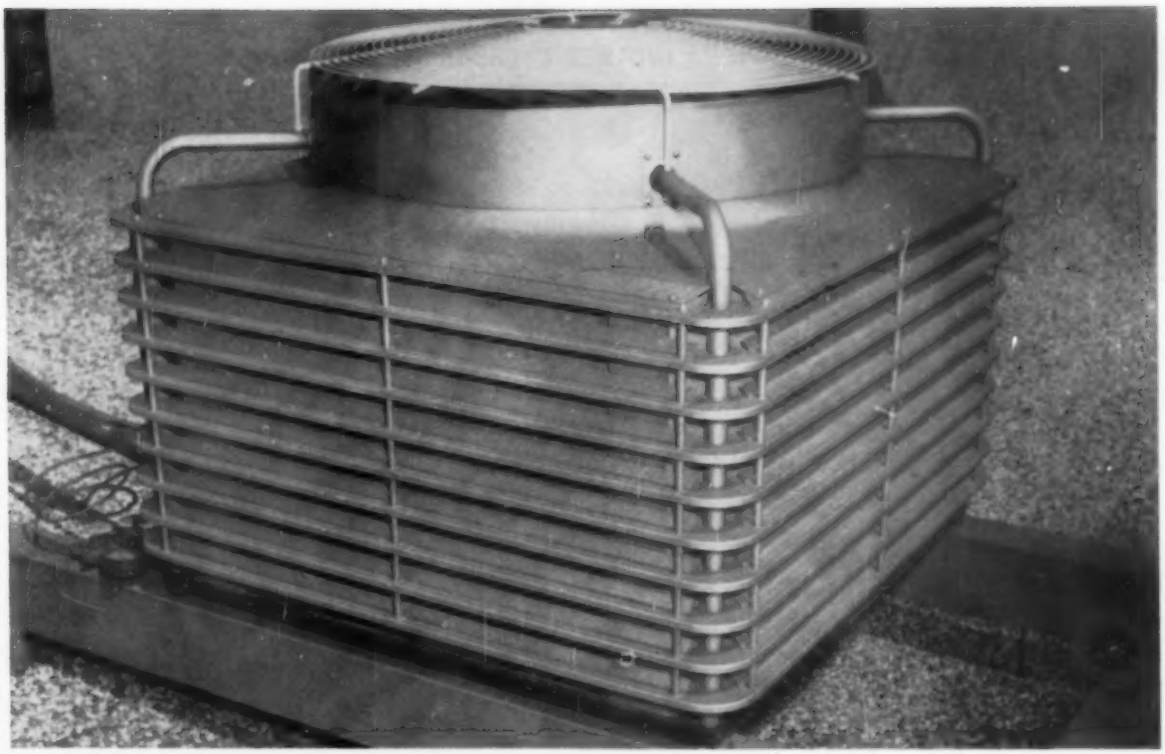

How Armco ALUMINIZED STEEL Type 2 Cut Costs and Improved Durability of Air Conditioner Housing

Special hot-dip aluminum-coated steel provides low-cost resistance to atmospheric corrosion, eliminates need for paint

A leading manufacturer of air conditioners formerly made the housings for the condenser units from cold-rolled steel. They had to be painted inside and out for surface protection and good appearance. Now, with all sheet metal parts made of Armco ALUMINIZED STEEL Type 2, *only the outside* is painted—and that because of a color identification of long standing.

Production Costs Down

Elimination of paint on the inside of the housing has reduced paint and labor costs 50%. And shop men report that with moderate care, parts can be fabricated of ALUMINIZED STEEL just as easily as with uncoated steel.

Better Durability

Originally the decision to use ALUMINIZED STEEL was based on tests which showed no rusting after 15 years' continuous exposure in an industrial atmosphere. Now service records prove that even under severe conditions the ALUMINIZED STEEL housings have lasting resistance to rust and corrosion, provide much longer service life.

Save on *your* production costs and give your outdoor products customer-attracting durability with the multiple advantages of Armco ALUMINIZED STEEL Type 2. Just fill out and mail the coupon for complete information.

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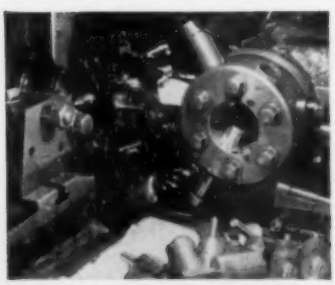
Short, fast-breaking chips indicate machinability of Rycut 20 —also save time by eliminating problems of chip clearance.

Rycut 20 alloy steel increases rotor output 40%, doubles tool life



Using Rycut 20 bars, Buckeye Tools Corp. machines motor rotors in less than two minutes floor-to-floor time.

Here's a manufacturer getting 34 rotors an hour compared with a previous 24—plus a 100% reduction in tool grinding.

How? By switching to Rycut 20 alloy steel. The company is Buckeye Tools Corporation, of Dayton, Ohio. A Ryerson alloy specialist recommended Rycut 20 (a low-carbon, lead-bearing alloy) for the rotor of their "Cadet" nibbler, an air-operated contour-cutter used on sheet metal, tubing and plastics.

World's fastest machining alloy steel in its carbon range, Rycut 20 is widely used for gears, cams, spindles, shafts and bearings. Like all other alloys from Ryerson, it carries a Certificate of Analysis and Hardenability which tells you exactly what steel you're getting and what to expect of it. A phone call to a Ryerson steel specialist at your nearby Ryerson plant may bring important cost reductions in your metalworking operations.

RYERSON CERTIFIED QUALITY

RYERSON STEEL

Member of the INLAND Steel Family

Principal Products: Carbon, alloy and stainless steel—bars, structurals, plates, sheets, tubing—aluminum, industrial plastics, metalworking machinery, etc.

JOSEPH T. RYERSON & SON, INC. PLANTS AT: NEW YORK • BOSTON • WALLINGFORD, CONN. • PHILADELPHIA • CHARLOTTE • CINCINNATI • CLEVELAND DETROIT • PITTSBURGH • BUFFALO • INDIANAPOLIS • CHICAGO • MILWAUKEE • ST. LOUIS • LOS ANGELES • SAN FRANCISCO • SPOKANE • SEATTLE

Casting for Customers

IN THESE DAYS of lessened production and increased competition, known as the 1958 recession, the hard-pressed seller is making the usual extra effort to convince the reluctant buyer that his product is the very best. The typical salesman is wining and dining prospects, handing out Madison Avenue brochures, arranging transportation from here to there – anything to indicate that he is a real nice guy, hoping that his attitude will reflect the status of the company and especially that of the product. Since competitor's salesmen are busy doing the same thing, all this results in is a very pleasant world for the buyer.

There is nothing new about the foregoing; similar methods have been used since Og first tried to convince Mogo that his "new and improved" arrowheads (Precision-Ground from Genuine Flint!) were much better for converting a local mastodon into raw steak than were Wug's old-fashioned clubs. Therefore, when a manufacturer comes up with something novel in the way of customer relations, it seems only reasonable to say something about it.

The management of General Motors' Central Foundry Division at Saginaw, Mich., have originated a "Casting Design Conference". They invite customers to a quiet, comfortably furnished, well-ventilated room and talk with them about castings – what they are, how they are made, what they can do, how they can be made to do more, and so on. There is nothing strikingly different in the material presented; the whole conference is just a straightforward offering of data that would help a customer in using castings in his product.

I attended the second session of this conference and found short, informative talks on radiography with cobalt-60, design improvements, shell casting, iron selection, tolerances and stress analysis. It might be interesting to present as an illustration a hypothetical case in which all these techniques are used. Lest someone's feelings may be hurt, it should be emphasized that what follows is purely fanciful – any relationship with living persons or actual machinery is purely fortuitous.

Thaddeus J. Blonk, design engineer for the Hootnanny 8, "the only car with power ashtrays", designs a frammis for the transmission gear box housing. Since this frammis has plenty of bosses, studs, webs, fillets, channels, and other intricate stuff, he decides a casting is needed. Stopping at Saginaw on the way to Los Angeles (he gets a little mixed up sometimes), he sees this big foundry and offers the designs for inspection. The foundry development engineer takes one look, becomes hysterical, and decides there is only one solution – appoint a committee. This committee gathers around the design, and, quick as a flash (three or four days), determines that the frammis is intricate, with close tolerances, and has to be fairly ductile. The material – malleable iron; the method – shell molding. Since

there is some doubt as to the feasibility of casting the part as designed, patterns are formed and sample castings are made. Radiography (with cobalt-60) and stress analysis (with strain gages and brittle coatings) show that the frammis is full of holes and would shatter from a loud sneeze. Obviously, something must be done. Checking on the intended application of the part, the foundry engineer discovers that by a few simple design changes, more practical tolerances can be obtained, cores eliminated, weight reduced, and more strength secured in the areas needed. The pattern is modified, more samples are cast, radiographed, stress-analyzed, and *voila,* the world's best frammis develops. Not only is it solid, but an atomic blast wouldn't shatter it. Vaporize it, maybe, but break it, no. Production techniques are devised, and soon Hootnanny 8's are rolling off the assembly line and the car sells by the millions. In two years of driving, the only part that is still intact is — you guessed it — the world's best frammis.

I warned you — this is a hypothetical case. While decidedly facetious, the preceding case history (!) does indicate the value of an up-to-date factory to a casting customer. Everything that is done — from appraisal of the original design to production of the item — is done to insure a serviceable part at a low cost. More than this cannot be expected by anyone.

Getting back to the actual conference at Saginaw, it also included a plant tour, and since the foundry covers an area the size of 15 football fields, this was quite strenuous. It is not only large and modern but the cleanest I have ever seen. Central Foundry's management apparently have a tiger by the tail. The original idea was to hold one or two conferences at Saginaw for customers' design engineers in Michigan, then to have similar meetings at Defiance, Ohio, and Danville, Ill., the other plant locations.

However, the invitations sent out have resulted in a far greater response than anticipated. By the end of March, seven conferences had been held at Saginaw with over 450 customers' representatives attending. Design engineers are being out-ranked by chief metallurgists, chief engineers, plant managers, master mechanics, buyers — in fact, it seems that everyone wants to get into the act. Furthermore, educators are becoming interested. Looking ahead, conferences every two weeks appear to be the order. The various orators now gaze wistfully at a period in the summer when they hope to step from the platform and get some of their regular work done.

If this "conference" scheme becomes prevalent, the engineering public may have to reconsider its opinion that the seller-buyer relationship is akin to that of two rival confidence men trying to outsmart each other. Quite an improvement, I should think. C.R.W.

Sideline for Valvemaker Means Lots of New Parts

WE HAD THE CHANCE to talk with Max Tauschek, who is chief engineer for Thompson Products' Valve Div., Cleveland (and also active on the ASM Handbook committee on valves). He said some things which will be of interest if you have had trouble getting precise parts from some of those hard-to-work alloys we hear so much about these days.

Now these parts don't have to be valves. In fact, that is the whole point back of this report. It stands to reason that if Max and his crew can make all kinds of valves, they can make a lot of other parts using the same techniques which they had to develop to keep ahead in the valve business. (Why didn't they think of this a long time ago?) So it's no secret now that Thompson is ready to supply various kinds of parts by the combination hot extrusion-forging method it uses for valve-making.

The new family of parts has been christened Valforgings. It includes anything up to 5 in. in head diameter and 12 in. in shaft length. Typical parts are impellers, drive shafts, throttling valves for high-pressure steam and spline clutches for generator drives. Others that can be produced as Valforgings include rotors, high-alloy bolts and fasteners, pistons for hydraulic control valves and integral gears and shafts for use where heat, corrosion, abrasion and high loads are encountered. In many applications, two parts now being welded can be made in one piece. In others, machine forming operations can be eliminated by coin-pressing head features into parts.

So far as metals that can be used, they can be almost anything for which the sales department can get an order. The tougher the alloy the better the process shows up. Parts have been made of stellite (this is supposed to be off-the-record), but it would be too tough for a steady diet. Thermenol-type aluminum alloys are still hard to handle but can be worked. As for the

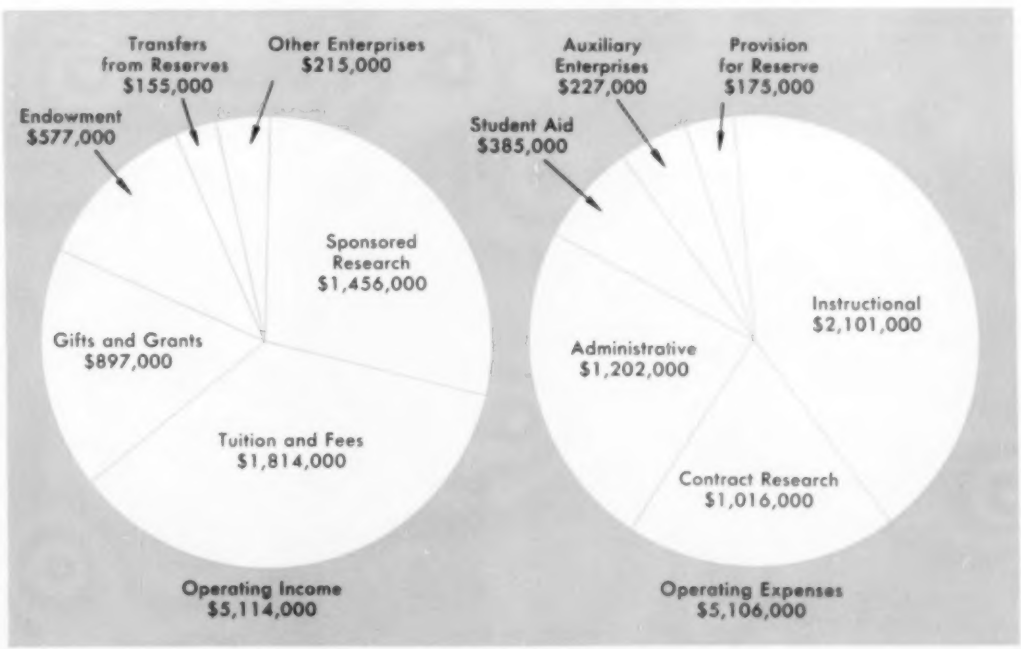
rest – the Inconels, Nimonics, A-286, N-155, Waspaloy, Udimet 500, stainless steels of all kinds, valve steels, and 1040 and lower alloys – they can be handled in stride.

Pictures of parts show grain flow lines which are continuous and symmetrical with the outside contour. This superior grain flow gives added fatigue and impact resistance to help meet specs for the most ticklish parts going into aircraft, missiles and nuclear reactors. Perhaps there are other proven (Thompson has made more than a billion auto valves this way) production methods in industry's shops that can be used for our tough missile and atomic parts. Might save money (and face, too) all around. Looks like a good idea, Max! A.G.G.

Colleges Need Money From Industry

THE MAIN PROBLEM before American engineering colleges, especially the privately endowed ones, is clearly set forth in the annual report of President Glennan of Case Institute of Technology. In this recounting of progress during his decade of service, Glennan notes that the number of students at Case has remained fairly constant near 2250, but the faculty has risen from 200 to nearly 300, and their salary levels greatly increased. (In 1947 the average salary for a 10-month year of a professor was a "shamefully low" $6000; now it is about $9500 – still far from adequate to compete with industry.) In the last 10 years the total operating expense of the institution has risen 150% – from $2 million to $5 million annually. Endowment and income from endowment have not kept pace with this, so the tuition has increased from $500 in 1947 to $950 at present. On the average, the institute gets only $800 per student, when scholarships and remitted fees are deducted, and this represents hardly 40% of the cost of the student's education. Hence the decision to raise the tuition fee to $1200 per year in the fall of 1958.

In this same decade $8,570,000 has been spent on five new buildings for instruction and three for student living. This certainly represents no mean accomplishment. Still, as President Glennan says, there is no cause for complacency; to keep an expanding program in balance as to faculty, curriculum and plant, he runs squarely into the perennial problem of finance. The goals demanded of engineering education in the world of 1958 will never be reached unless an adequate endowment is found. This means money, and this in turn depends on gifts from public-spirited men and corporation managements. E.E.T.



Ultrasonic Welding— a New Technique Grows

*By J. BYRON JONES**

Ultrasonic welding unites similar or dissimilar metals by introducing vibrational energy into the area to be joined. Solid-state metallurgical bonds, comparable in strength to those resulting from conventional methods, are produced. Thin gages, even in high-temperature, corrosion resistant metals, are readily welded. (K6r)

IN THE LAST FEW YEARS, the use of ultrasonics has grown greatly, and has reached production status in at least two applications. The minute, extremely rapid vibrations clean grease and dirt from parts, and locate large and small voids in various metal products. A new joining method is now added to the list of ultrasonic applications in industry. Metals difficult to weld by conventional means can often be united; they include several types of stainless steels, molybdenum, zirconium and its alloys, Inconel, tantalum, and others. It is also possible to join dissimilar metals and thin sections.

*A digest of a talk presented at a joint meeting of the Washington, D. C., Chapters of ⊕ and A.W.S. on Dec. 9, 1957. The speaker is associated with Aeroprojects Inc., West Chester, Pa.

Welding Mechanism

It might be well to begin with a discussion of the welding mechanism or, more precisely, our thoughts concerning this mechanism. Actually,

Fig. 1 — Diagram of Essential Mechanism for Ultrasonic Welding

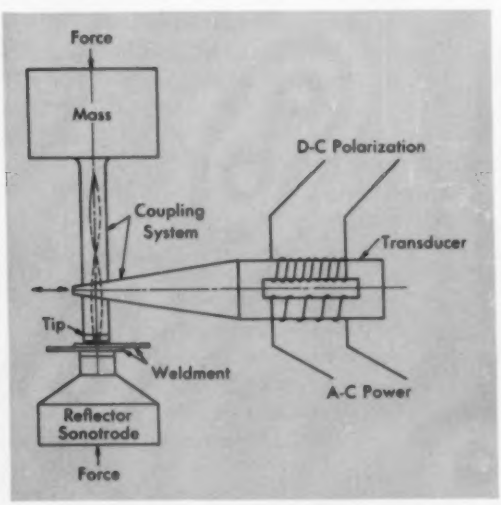
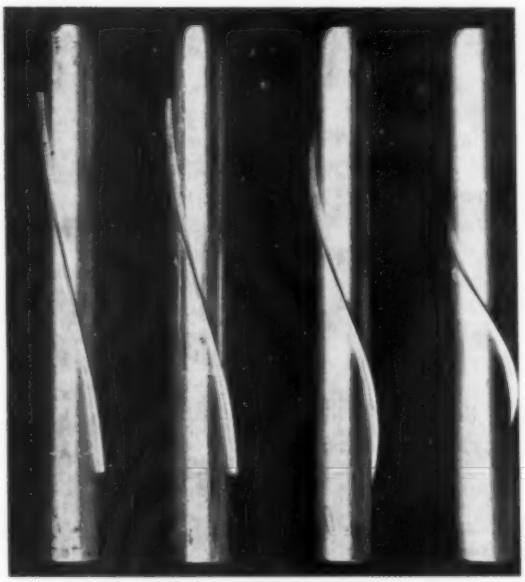


Fig. 2 — Jewelry-Type Spot Welder With Power Source



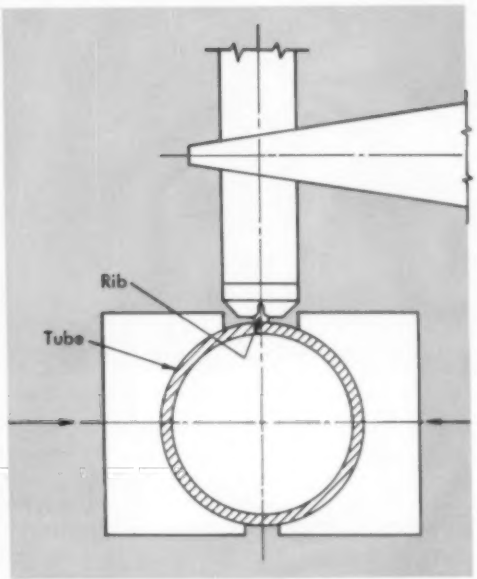


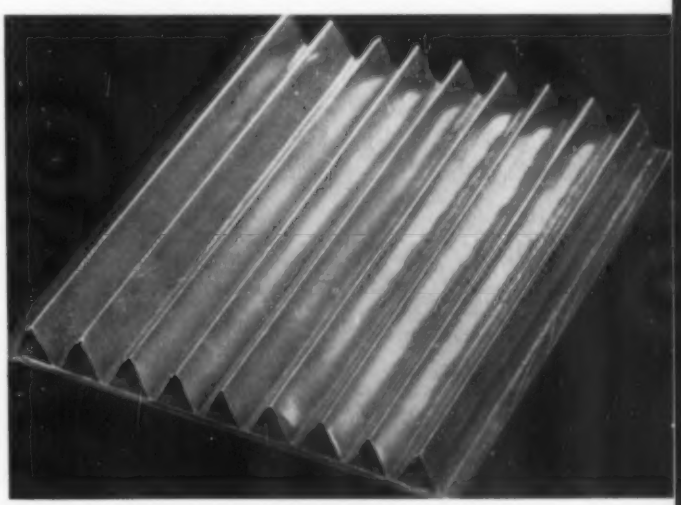
Fig. 3 – Tubing With Welded Spiral Ribs. Diagram of the specially designed welding tip at right

our knowledge is somewhat limited at present, but we know that several variables are involved. The vibrational energy delivered to the weld zone, the heat produced in the weld zone, the dynamic stress distribution, and the properties of the weldment materials all affect the quality of the junctions produced. The energy delivered to the weld zone results in a temperature rise which, though not small, does not cause melting on any ordinary microscopic scale. Plastic flow of the metal also occurs. Our experimental work has revealed many facets of the process. For example, thermocouples show that aluminum sheets reach 400 to 600° F. while being welded; Monel-aluminum combinations indicate temperatures approaching 1000° F. The temperature rise is obviously related to the thermal conductivity and specific heat of the weldments. Metallographic examination of welds in several materials reveals heat-affected zones, and occasionally a structural change indicates the temperature achieved. As an instance, the weld zone in a 6% Al, 4% V titanium alloy contained a two-phase structure of alpha plates in a beta matrix. Since the beta transformation of this alloy takes place at about 1800° F., it appears that the temperature in the weld zone rose above that figure. Properties which change with the temperature are transiently affected during the temperature rise.

The hardness of the metal is significant. Studies made with four tempers of cartridge brass show that more power is needed as the material becomes harder. On the other hand, very soft materials, such as fully annealed 1100 aluminum, can be more difficult to weld than some of the harder tempers.

In general, welds smaller in area are produced in harder materials. Furthermore, the weld area increases with sheet thickness up to a limiting value which varies with different materials and different clamping forces.

Fig. 4 – Thin Corrugated Sheet Ultrasonically Welded to Plate



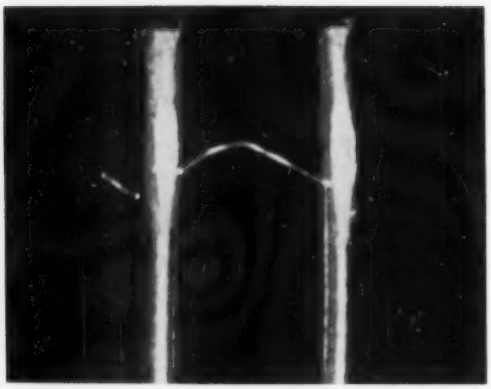


Fig. 5 – Tungsten Wire Welded to Copper Posts

Equipment

The ultrasonic process was first used for joining foil gages of soft aluminum and other metals. Since 1955, it has been looked at in connection with metal joining problems of heat exchangers, atomic reactor elements, electrical and electronic hardware, airframes, and a large number of everyday items. Its capabilities are being rapidly extended by the development of more powerful and effective transducer-coupling systems.

There are several basic arrangements, two of which are the laterally driven reed type and the lateral-drive type – both introduce ultrasonic vibration through a welding tip. The laterally driven reed type is illustrated by Fig. 1. The welding array consists of the ultrasonic transducer-coupling, its force-insensitive mount,* and a reflector anvil for concentrating of vibratory energy within the workpiece. A hydraulic, pneumatic, or spring system for applying static force to the weldment, and an electronic timer to control the duration of the ultrasonic pulse are usually included as well as a power supply and driving unit. Power inputs approaching 6000 w. have been applied to the transducer in some heavy installations and larger systems are forthcoming.

Jewelry-type welding of very small objects, such as small assemblies of thin foil gages of metal and wires for certain electrical and electronic applications, is possible with the 300-w. lateral-drive spot welder shown in Fig. 2; the power source is on the left.

Continuous-seam welding is regularly accomplished with both roller-type welders. Power is transmitted through a rotating transducer-coupling to a disk-like tip whose peripheral speed is

*Force-insensitive mounts prevent the resonant frequency from shifting with force applied to the system, and largely prevent energy losses to the support systems.

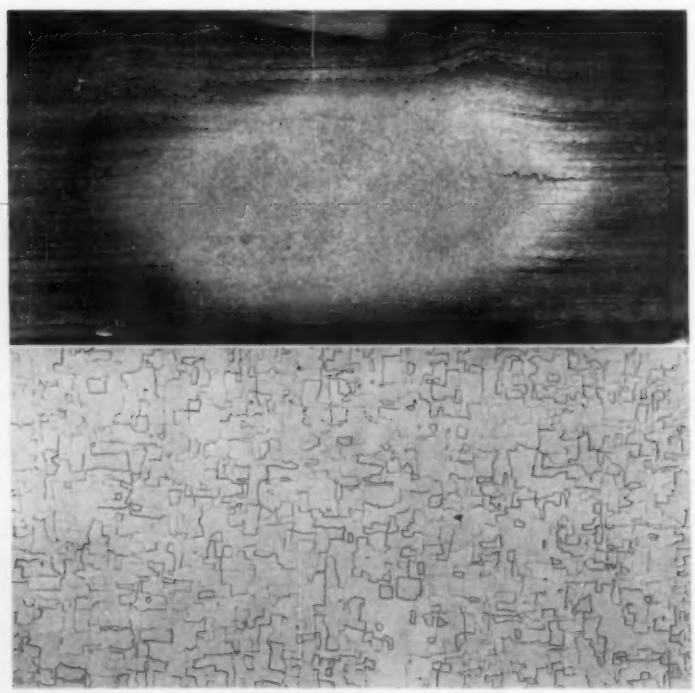


Fig. 6–Spot Welded Titanium Sheet. The light area (27×) is the heat-affected zone; its structure is shown below at 150×

Fig. 7—An example of Distortion Occurring at the Interface. Nickel (bottom) welded to Kovar, 300×

matched by the traverse speed of the welder bed or a wheel. Seams have been produced in thin gages at welding speeds up to about 20 ft. per min. with the continuous technique.

An ordinary 220-v. factory-type power line will handle the heaviest equipment developed to date, and the welding unit itself may be as much as a hundred feet away from its driving gear.

Applications

Early work was concerned primarily with spot welding simple lap joints in flat sheet. Techniques and equipment have since been devised for making a variety of simple and complex junctions. A few illustrations follow:

While there are sheet thickness limitations in vibratory welding, they apply only to the thinnest member of the weldment; the other member may be heavy sheet or plate. It is hard to achieve satisfactory junctions of substantial area between parts with greatly differing cross sections by most welding techniques. However, with this process, small ribs (0.25 in. high) have been welded to cylindrical rods and tubes, as shown in Fig. 3. The ribs were attached at spiral pitches ranging from 12 to 30 in. to rods approximately 2 in. in diameter. To achieve these welds, the straddle-type welding tip also shown fits over the web of the rib so that the entire rib base area is welded. Originally, fully automatic equipment produced 12 overlapping spots per in. at about 3 in. per min. Another example is the configuration illustrated by Fig. 4. The bottom of each corrugation has been ultrasonically seam-welded to the base plate. Equipment has been devised to produce multiple seam welds simultaneously; with these gages – the thinnest member is about 0.010 in. thick – welding speeds of 20 ft. per min. have been reached.

Numerous instances in which other welding techniques encounter difficulty exist in jewelry-type welding, such as shown in Fig. 5. A 1.5-mil tungsten wire has been welded across two 25-mil copper posts with welding tips designed to provide adequate drive and support for the weldment.

Metallography

The microstructures of welds produced by the ultrasonic technique offer an insight into the joining mechanism. A striking example is illustrated by Fig. 6; it is a weld between two sheets of 0.032-in. 8% Mn titanium. The light area is the heat-affected zone; transformation has occurred with the high-temperature structure being retained on cooling. An excellent union between the two sheets has been achieved by recrystallization and growth.

Another characteristic of ultrasonic welds is the considerable amount of working which takes place at the weld interface; meanwhile, the surfaces contacted by the welding tips may not be seriously affected.

Table I – Weld Strengths of Typical Alloys

Material and Type	Sheet Gage	Tensile-Shear* Strength
Type 316 Stainless steel	0.010 in.	220 ± 10 lb.
	0.018	440 ± 50
Inconel	0.010	170 ± 70
	0.020	220 ± 105
5Al-2.5Sn titanium alloy (A 110-AT)	0.028	1950 ± 120
6Al-4V titanium alloy	0.025	1230 ± 60
8Mn titanium alloy (C 110-M)	0.032	1730 ± 200
Zircaloy-2	0.020	615 ± 20

*Based on 90% confidence limits.

As an extreme example of this effect, a bond between nickel and gold-plated Kovar* is shown (Fig. 7). The two 3-mil sheets have been severely deformed to about the same extent; this often occurs when the two materials have about the same hardness. Local interfacial deformation is about 60% of the total weldment thickness, yet there is no particular external deformation. Most of the gold plating was extruded toward the edges of the weld and is not visible; the nickel is essentially in contact with the bare Kovar.

We have produced a variety of bimetal combinations: They include, among others, brass, copper, steel, or aluminum to zirconium plate; platinum, molybdenum, brass, Inconel, or silver-manganese to various steels; tungsten, copper, or gold-platinum alloy to nickel; copper or silver to brass; molybdenum or tantalum to aluminum; and a palladium-ruthenium alloy to a silver-gold alloy.

Table II – Weld Ductility Data

Material	Sheet Gage	Cross-Tension Strength	Tensile-Shear Strength	Tension-to-Shear Ratio
17-7 PH stainless steel				
Annealed	0.005 in.	51 lb.	116 lb.	44%
	0.012	115	287	40
	0.020	187	544	34
Solution heat treated	0.005	47	141	33
	0.012	108	362	30
	0.020	61	668	9
Heat treated and aged	0.005	63	155	41
	0.012	76	361	21
	0.020	84	471	18
Titanium alloys				
6Al-4V	0.025	260	1220	21
8Mn	0.032	440	1750	25

Weld Strength

Adequate weld strengths are attained by the ultrasonic process, as Table I illustrates. All data are obtained from single-lap spot welded specimens.

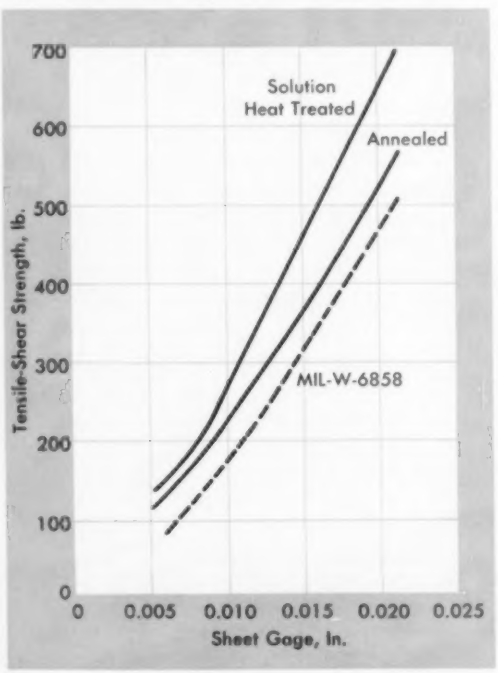
The welds can meet stringent requirements; for example, in Fig. 8, the dotted line shows the minimum spot weld strength needed to meet Military Specification MIL-W-6858, which applies to steels having a 90,000 to 150,000-psi. ultimate strength. Both annealed and heat treated 17-7 PH stainless steels fall in this range; ultrasonic welds in each are obviously adequate.

In a few instances, ultrasonic welds have been tested in cross-tension as well as in tensile-shear; their ratio is considered to be an indication of the weld ductility. Table II shows the results of tests performed on 17-7 PH stainless steel and two titanium alloys.

Conclusion

We have attempted a review of some basic principles and some present capabilities of the ultrasonic welding process, particularly in the joining of high-temperature and corrosion resistant materials. The future of this new method is limited only by the power of the equipment now in use; however, more powerful machines (for the welding of heavier gages) are being devised constantly. Based upon our past progress and our presently planned development effort, we can show nothing but optimism.

Fig. 8 – Weld Strength of 17-7 PH Stainless Steel

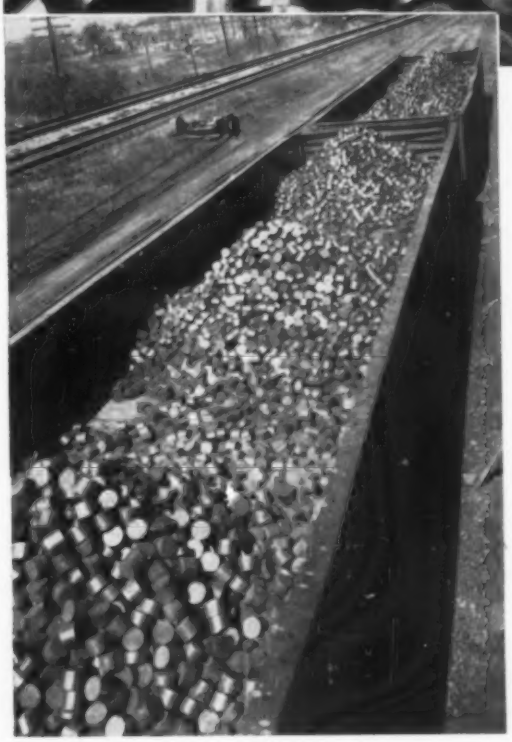


*Kovar is used in several types of electronic tubes. The alloy contains 29% Ni, 17% Co, 0.2% Mn, and Fe; it has the same coefficient of expansion as glass.

Fig. 1 – Briquettes From the Direct Reduction Process Are About 4 In. in Diameter and 3 to 4 In. Thick. They weigh 6 to 8 lb. Their surface is smooth and clean; they analyze up to 97% iron

The R-N Process for Direct Reduction of Iron Ores

STAFF REPORT



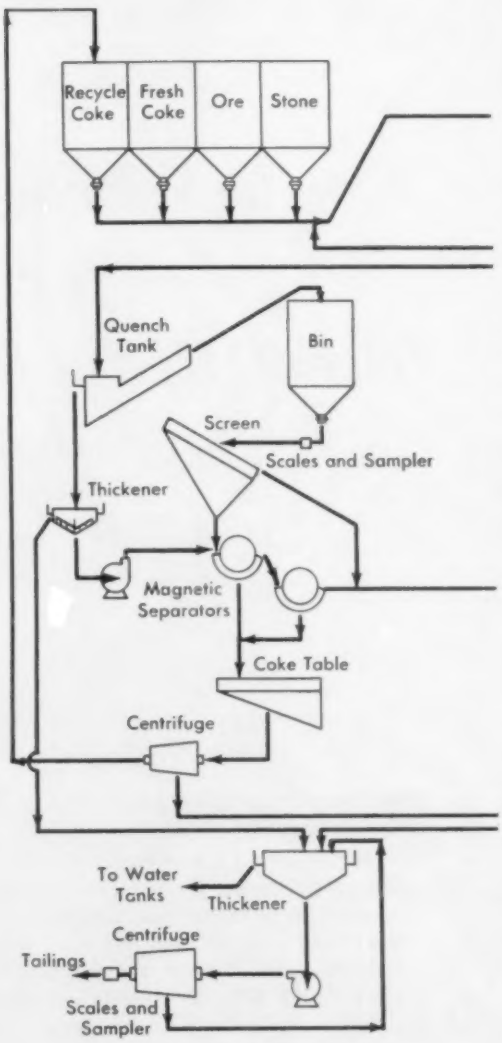
This advanced process economically produces iron concentrates which are suitable as feed for blast furnaces, cupolas, openhearths and electric furnaces. It can be used for treating low-grade ore or with high-grade ore to produce metallics. Full-sized plants have been designed and indications are that the combination of an R-N plant with electric furnaces would in many cases be cheaper to operate and involve less investment than a blast furnace-openhearth combination. (D8j, D5g, D1h; Fe, RM-n)

TWO COMPANIES with widely different backgrounds can work together to solve problems that neither can handle advantageously alone. This is the story behind the R-N process – today's success story on the direct reduction of iron ore.

The process is a joint development of the Republic Steel Corp. and the National Lead Co. Work on the process has extended over the past 13 years. It was initiated by the National Lead Co. to recover titanium values from titaniferous iron ores. Much early work was done in Norway.

When it appeared that the process might have value for beneficiation of iron ores, National Lead joined forces with Republic Steel to make the investigation. After extensive laboratory studies, a pilot plant was constructed in Birmingham, Ala., which has now treated over 100,000 tons of iron ores. Details of the process and re-

Fig. 2 – Flow Diagram of the R-N Pilot Plant at Republic Steel Spaulding Mine on Red Mountain outside Birmingham, Ala. This plant can handle 175 tons of U. S. Southern Clinton ore per day. It has treated over 100,000 tons of iron ores



sults of steelmaking tests on the products were given at the national convention of the American Institute of Mining, Metallurgical, and Petroleum Engineers in New York last February.

Speaking for National Lead Co. were Alex Stewart and H. K. Work (New York University, consultant for National Lead Co.). E. C. Smith, chief metallurgist and director of research, and D. E. Babcock, metallurgical engineer, presented the Republic Steel story.

How It Works

The R-N process involves the direct reduction of iron ores in a controlled atmosphere and under controlled temperatures. This is done in a rotary kiln, below the melting point of iron and below the melting point of practically all the constituents of the charge, using nonmetallurgical solid carbon fuels.

The process gives products which are suitable as feed for blast furnaces, cupolas, openhearth and electric furnaces. Depending on the mineralization of the ore, concentrates in the range of 95% total iron (90% or better metallic iron) and less than 2 to 3% silica can be produced, with over-all iron recovery of 85 to 90%.

With some low-grade iron ores, the process gives two products; 60 to 80% of the over-all product contains 90 to 95% total iron (about 90% metallic iron) and less than 3% silica. The remaining 20 to 40% of the over-all product may contain 80 to 90% total iron (60 to 80% metallic iron) and an average of 8% silica.

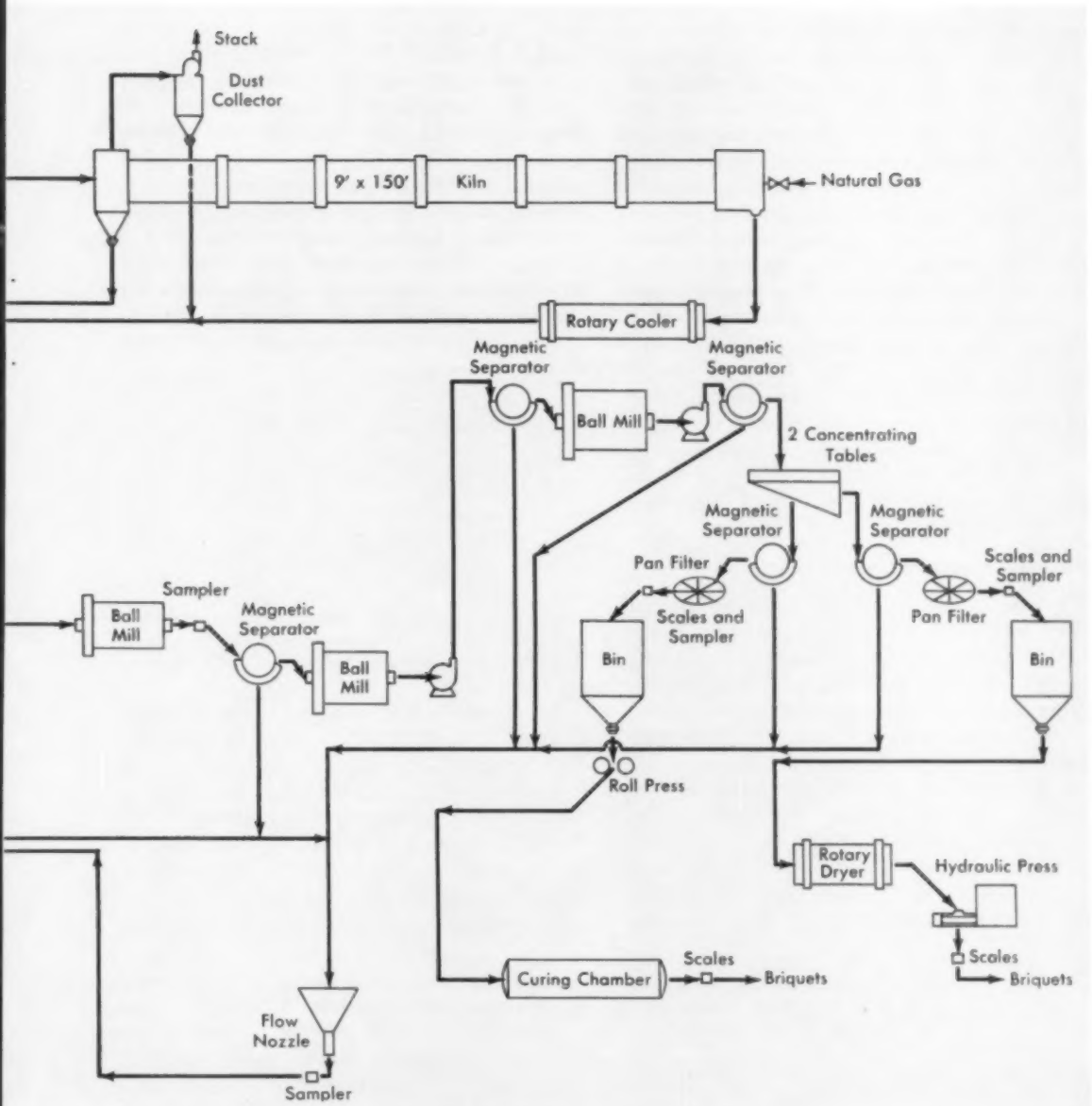
The richer grade of product (95% total iron, less than 3% silica) is a suitable feed for the electric or openhearth furnaces. The remainder (90% total iron and about 8% silica) is particularly good for the blast furnace.

The Pilot Plant

The R-N process is in the well-developed pilot plant stage. In processing U.S. Southern Clinton ore, the pilot plant, shown schematically in Fig. 2, treats about 175 tons of ore per day. On the basis of this operation, full-sized plants have been designed and the process is now ready for commercial development.

In the process, crushed and sized ore (or balled fines, depending on the character of the ore) in a size range of up to 1 in. is fed to a rotary kiln. Along with the ore, an excess of carbonaceous fuel is fed into the kiln in an amount several times the carbon requirement, resulting in recycling 75% of the carbon for reuse. (The solid fuel may be coke breeze, char, Disco, culm, anthracite fines and the like.)

This provides for controlled combustion with an efficiency of 75 to 80% of the stoichiometric carbon requirement. Limestone and dolomitic limestone (depending upon requirements) are



fed into the kiln to arrest the sulphur in the ore and in the solid carbonaceous fuel.

The kiln may be fired with gas or oil and is equipped with air tubes with inlets spaced along the length of the kiln for control of the temperature and to control the composition of the atmosphere. As the ore travels through the kiln countercurrent to the flow of heat, it is dried, preheated and reduced. Of particular importance is the fact that reduction is always conducted at a temperature below the melting point of iron and below that of substantially all of the other constituents in the charge.

The kiln temperature used for U.S. Southern Clinton ore is in the range of 1800 to 2000° F. The average residence time required in the optimum operating temperature zone is in the order of 3 to 5 hr. at an average feed rate of 7 tons per hr.

The product from the kiln is cooled, either slowly or rapidly as requirements dictate. This maintains the iron in a passive condition to cor-

rosion and prevents reoxidation and loss of metal.

The kiln discharge materials are separated by screening and by gravity and magnetic means. The excess solid carbon fuel is cleaned, dewatered and returned to the kiln. The magnetic portion containing the reduced or metallized iron is freed of gangue by grinding, magnetic and gravity separation procedures.

The beneficiation step has several unusual features: The product from the kiln is not a magnetic oxide, which is often removed from ores by magnetic separators. It is largely metallic iron. This means it has magnetic and gravity characteristics which allow it to be readily separated from its gangue. Furthermore, a combination of magnetic and gravity separation provides an optimum degree of over-all recovery. This is one of the factors contributing to the excellent recoveries of iron and to the quality of the concentrate.

Electric Furnace Tests

It was decided to produce sufficient quantity of the high-grade R-N product and make electric furnace steel to see how it would compare with scrap. This was produced from a high-grade Adirondack ore which gave a single product which analyzed over 95% iron. The tests were made at the Republic plant in Chicago, which has 95-ton electric furnaces and personnel with skill in tonnage carbon steelmaking. The test was simply scrap replacement with no quality problems involved. The instructions to the shop, says Republic's E. C. Smith, were "to examine the melting characteristics of R-N briquettes as straight replacement for scrap in the electric furnace process".

A total of 2064 tons of briquettes were shipped from the pilot plant to Chicago. Between Feb. 18 and April 14, 1957, 58 heats with varying percentage of R-N briquettes were compared with 58 companion heats using scrap to determine differences in melting performance as the percentage of R-N briquettes in the charge was increased. These heats were made in pairs – an R-N heat was followed by a companion scrap heat for comparison.

The analysis of the briquettes used in the Chicago tests was:

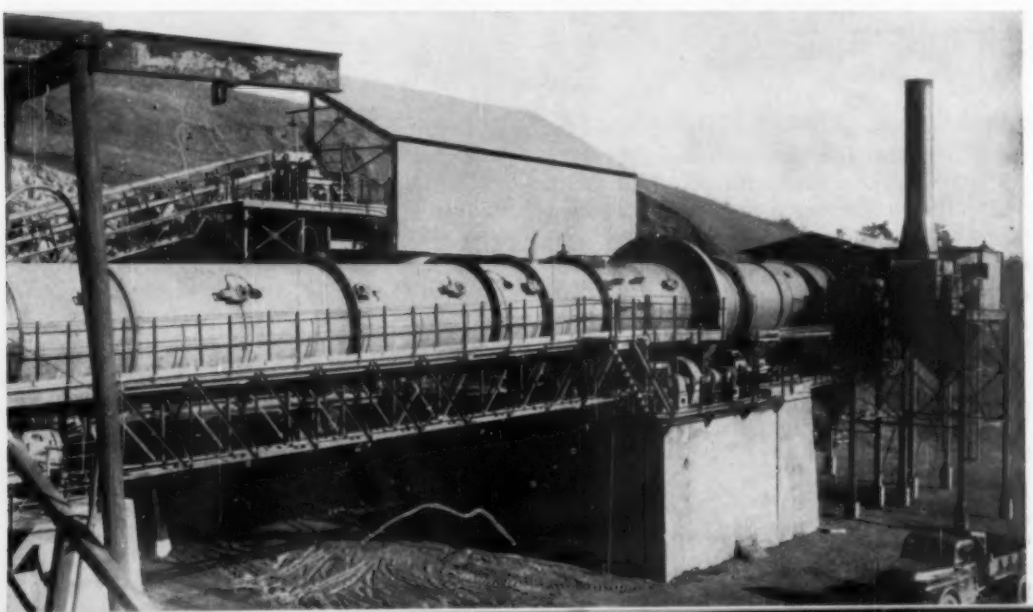
Iron	95.20%
Metallization	92.41
Carbon	0.28
Manganese	0.07
Phosphorus	0.029
Sulphur	0.019
Silica	0.51
Titanium oxide	0.57
Alumina	0.34
Lime	0.17
Magnesia	0.17

The total slag-forming materials in this analysis are about 2.75%.

The cylindrical briquettes had a mean diameter of about 4 in.; thickness varied from 3 to 4 in. They weighed from 6 to 8 lb. each and gave a bulk density of 225 lb. per cu.ft. in the charging box. These physical properties approached the density of heavy bloom butt scrap as charged to the furnace. The briquettes were shipped without special handling or preparation.

Some observations which were made during

Fig. 3 – Ore, Coke and Limestone Are Fed Into This Rotary Kiln for the Pilot Plant. It is 9 ft. in diameter and 150 ft. long. As the ore travels through the kiln, it is dried, preheated and reduced



Why There Is Interest in Direct Reduction of Iron Ores

1. High-grade open pit ore reserves within the U.S. are rapidly being depleted.

2. Metallurgical coking coals for the blast furnace are becoming less available and more expensive. This spurs the need for higher grade iron feed stocks which require less coke. Chars (low-grade noncoking coal) can be used in direct reduction processes.

3. Capital investment for blast furnaces becomes more precarious unless high-grade feed can be developed on a competitive basis with present feed stocks.

4. Direct reduction to produce metallics, followed by electric furnace processing, requires the lowest capital investment for new steelmaking capacity.

5. In U.S. low-grade reserves, the ratio of nonmagnetic to magnetic ores is about 10 to 1. This is the basic reason for developing an economic direct reduction process.

6. Scrap does not offer a uniform composition for steelmaking at uniform cost.

the tests follow: The R-N briquette has a real advantage for the melter, and this was quickly recognized in the gentle boil on melt-in which insured even bath temperature and action – so useful in fast-working furnaces.

Requests for comments brought out the fact that there was only one real criticism. The 225-lb. per cu.ft. bulk density, as charged, tended to place an upper limit on their use at less than half the weight of the total charge. This objection can be eliminated by modifying the shape of the briquette.

However, the good strength characteristics of the briquettes permit easy handling and storage. Loading for charging either into buckets or boxes is fast. The potential speed-up of operations pleased the melt shop crews.

The uniformity of product both in density and electrical conductivity made for surer operation because no nonconducting spots were encountered. This is important where very heavy power input for melt-down is used. The risk of power interruption and broken electrodes is nearly eliminated.

Where the composition of the material is known to be free from harmful incidental alloying elements, the melter need not wait for special laboratory analyses. He can proceed with much more speed toward the completion of each phase of the operation. Freedom from dirt and contamination gives smaller slag volumes which are a problem even when molten pig iron is used, due to such slag-forming elements as silicon and phosphorus.

In comparing R-N heats with scrap heats, no significant differences were found in operational factors, such as operating delays, charge to tap time and patching time. Generally the power input and yields were essentially the same as for scrap heats. Further studies are planned to pin down some of the fine points on these two factors.

It is wrong, however, to look at high-grade R-N concentrates as being just a competitor of scrap. National Lead people say that, where a new installation is being considered, there is every indication that the combination of an R-N plant with electric furnaces would be cheaper to operate and would involve less investment cost than a blast furnace-openhearth system.

Blast Furnace Tests

In the blast furnace, the use of R-N product decreases coke consumption and increases output because most of the iron is already reduced. The blast furnace is a relatively inexpensive way to melt the iron and to complete the refining operation.

During carefully controlled runs, 6000 tons of R-N briquettes were charged in a Republic Steel blast furnace. The briquettes were considered as a new added component – not as a replacement material for any specific ore.

In one test period, 7% of the burden by weight was in the form of R-N briquettes. However, because of the higher iron content, this 7% actually represented about 13% of the total iron units charged to the furnace. Substantial coke savings were realized compared with charging an equivalent quantity of ore. Calculations showed the savings to be about 0.49 ton of coke per ton of briquettes used. The iron production was increased about 10 tons per day, per 1% of briquette added.

An additional economic benefit from the use of R-N briquettes is the lower phosphorus content of the pig iron produced. This is particularly important because of the high-phosphorus ores in the south.

Biographical Appreciation

G. Mac Donald Young
President, A.S.M., 1957-58

When he joined Aluminum Co. of Canada, Ltd., in 1930, G. MacDonald Young was the first Canadian physical metallurgist the company had hired. But firsts seem to come natural to "Mac" Young – as he is known to his friends. As president of the American Society for Metals, he is the first Canadian to hold this office.

Mac has spent his entire working life with one organization – which he says is less unusual in Canada than in the States. He joined Alcan as metallurgical assistant in its Toronto Works after graduating from McGill University with a B.Sc. in metallurgy. Two years later he became the plant's chief metallurgist.

Toronto provided a unique opportunity to learn the aluminum business, Mac recalls. Although the plant was small, its operations involved almost all types of aluminum fabrication – foundries, sheet and foil production, and the manufacture of closures and utensils.

In 1940, Mac was appointed chief metallurgist of the then-new plant at Kingston. The position was a key one for the Canadian aluminum industry: At that time it was advancing from a technology which dealt mostly in a few common alloys to one which was being called upon to supply many specialized compositions for industrial applications. Mac had a major part in developing fabricating practices for the new aluminum alloys required for Canada's aircraft building program during World War II.

Four years later, he became chief metallurgist of the general technical department – fabrication division, and in 1946 was appointed technical director – the position he holds today.

Mac was born in Saskatoon, a western Canadian city of some 75,000 and the home of the University of Saskatchewan, which he attended for two years in general engineering. Mac recalls that he did a summer essay at the University on the geology of Saskatchewan, and this, together with the glamour of the rapidly expanding mining industry in Canada, set him looking for instruction in the metals field.

This took him to McGill University in Montreal. He enrolled in mining but during the first two weeks realized that his interests lay more in metallurgy and switched his course.

The experience of being 2000 miles from home and having to make a decision on a career still sticks in Mac Young's mind. He will tell you that one of his greatest interests in A.S.M. work is student affairs because he once had the problem of finding what he wanted to do.

The aluminum business was a great deal smaller and simpler in 1930 when Mac Young started in Toronto than it is today. "In those days", he recalls, "we only rolled 2 S and 3 S mostly for cooking utensils and storage vessels. There were only a handful of casting alloys.

"This is quite a contrast to our present alloy list which includes about 40 wrought and 30 casting compositions, plus some 160 special alloys made up at the request of ingot customers." Mac's company is the world's second largest producer of aluminum.

Metallurgical research has fostered growth of the aluminum industry by developing alloys for new applications and utilization techniques. And it will continue to be that way, says Mac. Today's expanded capacity assures ample metal for new uses, and research is being directed into broadening the fields of application.

Mac was quite an athlete in university days. He could run the 100 yards in 10 sec. One of his first trips to the east was to the 1927 Olympic Trials in Toronto. It was through sports that he met his wife, the former Marion Wylie of Saskatoon, who was ladies' western broad jump champion. The Youngs have two daughters: Heather, 10 years old, and Kaireen, 14.

In his off hours Mac likes to paint in oils and build furniture. He has a workshop that would stagger the average hobbyist. His biggest project so far was building a complete bedroom suite for his two daughters.

His interest in painting dates back to the time when as a boy he won a prize at a Saskatoon exhibition for two of his water colors. While at Kingston, he attended some art classes at Queen's University. His professor accused him of being "too meticulous and detailed . . . wanting to put every leaf on all the trees". Mac says he supposes it's his training in a precise science that accounts for it.

Mac has been a member of A.S.M. since he joined the Ontario Chapter in 1937. He has served as a member of the executive committee of the Montreal Chapter since 1947, and was chairman of the chapter in 1951-52. He was a national trustee 1953-55.

He is also active in other professional and technical associations. He has been aluminum representative on a number of Canadian Standards Committees and a member of the administrative board of the Canadian Welding Bureau. He is a member of A.I.M.E. and A.S.T.M. and is Canadian correspondent for the Institute of Metals.

Mac feels that all members have a great responsibility to tell young people about the rewarding career metallurgy offers and to encourage them to enter this field.

Selection of Steels for Springs

By H. J. ELMENDORF*

The mechanical properties of spring wire and springs are related; by knowing the wire tensile strength, the spring design stress can be predicted and the proper spring steel can be selected.
(Q21, Q23b, Q27a; ST, SGA-b)

IN RECENT YEARS, the designer of springs has been faced with a maze of widely varied information on the selection of spring materials. While considerable information is available on design stresses, little data have been published that relate the mechanical properties of the spring wire with those of the springs produced from the wire. Published information indicates that there is a wide difference in stress values for identical spring materials. Such differences should not exist. The same spring materials are produced by many manufacturers to closely controlled mechanical properties as required by various specifications. Therefore, it is reasonable to assume that the published values vary because they are based on different criteria. Standard test procedures are needed.

In the spring industry, all cold wound, helical

*Chief Spring Engineer, American Steel & Wire Div., United States Steel Corp., Worcester, Mass.

Table I – Composition of Spring Steels

Type*	C	Mn	P	S	Si	Cr
Music spring wire	0.88 - 0.93	0.35 - 0.38	0.008 - 0.010	0.016 - 0.022	0.19 - 0.28	—
Hard drawn spring wire	0.61 - 0.71	0.94 - 0.98	0.010 - 0.031	0.037 - 0.044	0.21 - 0.22	—
Oil tempered spring wire	0.57 - 0.66	0.62 - 0.99	0.009 - 0.018	0.036 - 0.040	0.21 - 0.23	—
Valve spring wire	0.68	0.66	0.014	0.016	0.30	—
Chromium-vanadium†	0.50 - 0.51	0.78 - 0.79	0.010 - 0.013	0.020 - 0.024	0.30 - 0.34	0.94 - 1.04
Chromium-silicon	0.55 - 0.57	0.67 - 0.80	0.015 - 0.023	0.018 - 0.026	1.35 - 1.60	0.65 - 0.77

*The first two are cold drawn to achieve the desired mechanical properties; the last four are all heat treated.
†Vanadium content is 0.22%.

compression and extension springs are normally stress-relieved. Otherwise, early failure may occur through setting, since the spring has only about 40 to 70% of the resistance to set that it has in the stress-relieved condition. While it is known that the stress-relieving of cold wound springs enhances their properties, it is of value to know the effect that identical stress-relieving heat treatments will have on the same spring materials before coiling. A series of six spring steels in three wire diameters (0.098, 0.148 and 0.250 in.) have been studied. Pertinent information is given in Table I.

The music spring wires and the hard drawn spring wires were process heat treated and cold drawn through a series of dies; they achieve their mechanical properties primarily through extensive cold work. The other steels were heat treated after drawing to finish size. This heat treatment consists of continuously austenitizing the wire, followed by quenching (usually in oil), and tempering in a molten lead bath. Accurate speed and temperature control is essential to attain optimum mechanical properties.

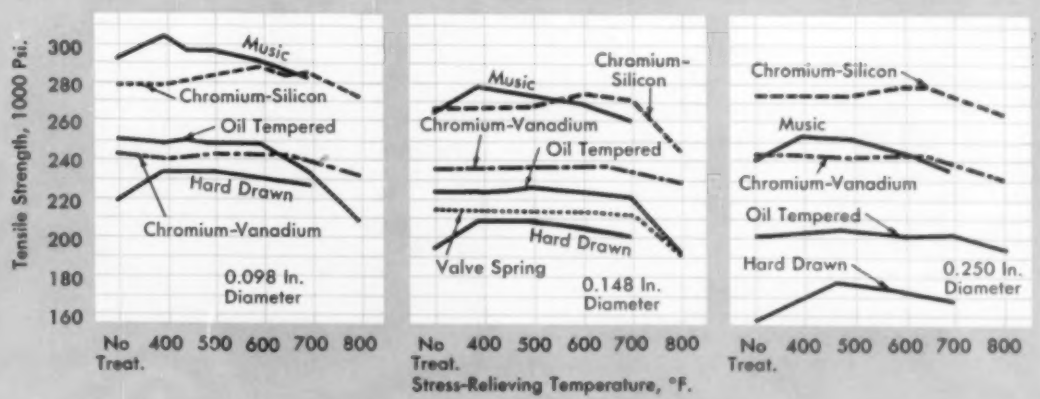
Table II – Optimum Stress-Relieving Temperatures

Type	Temperature	Time
Music spring wire	450 to 500° F.	30 min.
Hard drawn spring wire	450 to 500	30
Oil tempered spring wire	450 to 500	30
Valve spring wire	575 to 625	30
Chromium-vanadium	600 to 700	30
Chromium-silicon	600 to 700	30

Each spring steel, in three different wire sizes, was stress-relieved at different temperatures for 30 min. and then air cooled to room temperature. (Previous tests have shown that the properties of the steel are not improved by heating longer than 30 min.) Three samples of each type of steel (in each size of spring wire) were tested in tension and the stress-strain curve for each sample was drawn. Figure 1 shows the ultimate tensile strength, and Fig. 2 the elastic limit; all are average values.

Stress-relieving affects the ultimate tensile strength and the elastic limit, particularly for the music wire and the hard drawn spring wire.

Fig. 1 – Effect of Stress-Relieving on Tensile Strength



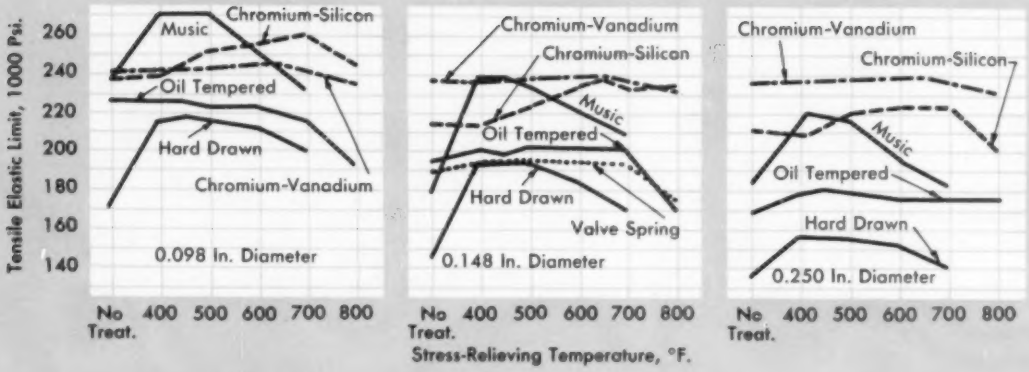


Fig. 2 – Effect of Stress-Relieving on Tensile Elastic Limit

Both are increased by heating in the 400 to 500° F. range. The oil-tempered spring wires, except for the chromium-silicon grade, show little change in either ultimate tensile strength or elastic limit until 700° F. Both properties then drop because of temper softening. The chromium-silicon spring material increases in both ultimate tensile strength and elastic limit with stress-relieving to approximately 700° F.

Spring Properties

Each grade of spring wire was automatically cold coiled into springs and stress-relieved in the same manner employed for the spring wire tests. The Spring Index* for the test spring was:

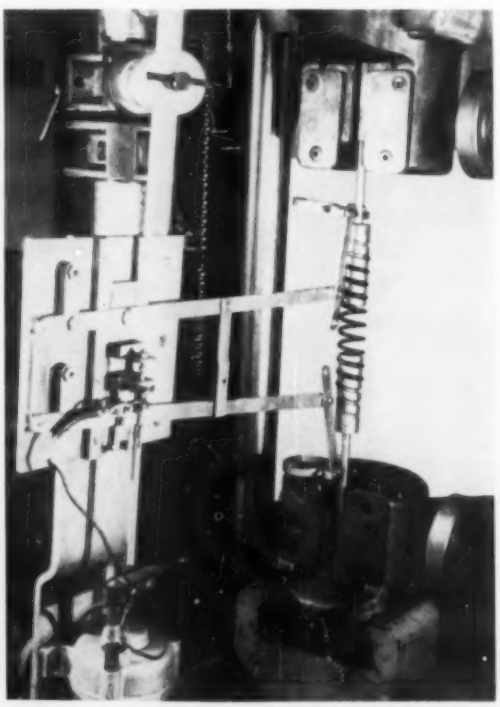
Spring Wire Diameter	Spring Index (D/d)
0.098 in.	4.6 to 4.75
0.148	5.9 to 6.3
0.250	6

Each spring was individually measured and tested. The testing procedure is an adaptation of the wire sample tensile testing. A pintle was inserted into each end of a spring. Tension loading followed with the load-extension curve being autographically recorded (Fig. 3). The spring torsional elastic limit was then calculated, and a graph of the results is shown in Fig. 4. This method eliminates the end effect that is normally associated with the testing of springs in compression.

These curves indicate the optimum stress-relieving temperature and the maximum spring torsional elastic limit for each spring material. Higher spring torsional elastic limits than those shown can be obtained by cold setting operations. The stress-relieving treatments (for room temperature and static conditions) to obtain optimum values of the spring torsional elastic limit are shown in Table II.

Spring torsional elastic limits, commonly known as spring design stresses, consider only the

Fig. 3 – Installation of Spring And Pintle Assembly in Testing Machine



*This is a ratio which relates the mean spring diameter, D, to the wire diameter, d. The mean spring diameter, D, is equal to the outside diameter less one wire diameter.

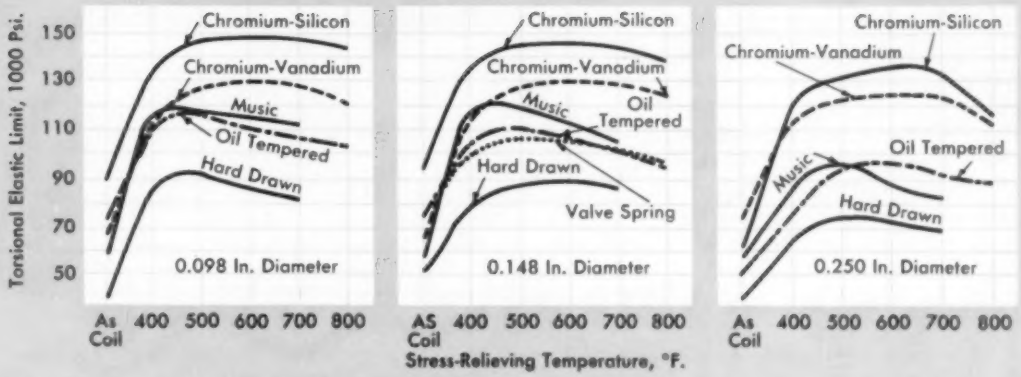


Fig. 4 – Effect of Stress-Relieving on Torsional Elastic Limit of Springs

Table III – Effect of Spring Index on Spring Torsional Elastic Limit

Type	Spring Index	Wahl Correction Factor	Spring Torsional Elastic Limit	
			Uncorrected	Corrected
Music spring wire	4.60	1.33	118.000 psi.	157,000 psi.
	8.38	1.16	119,000	138,000
Hard drawn spring wire	4.60	1.33	92,000	122,000
	8.50	1.16	93,000	108,000
Oil tempered spring wire	4.75	1.32	118,000	156,000
	8.68	1.15	113,000	130,000
Chromium-vanadium	4.75	1.32	126,000	166,000
	8.65	1.15	118,000	136,000
Chromium-silicon	4.75	1.32	148,000	195,000
	8.26	1.16	156,000	181,000

stresses in pure torsion. They do not include the additional stresses caused by the curve of the wire and the shear load, which vary with the spring index; a formula developed by A. M. Wahl (known as the "Wahl Correction Factor") takes into account these two effects.

During our investigation, some exploratory work was carried out to determine tentatively the effects of "Spring Index" on the spring torsional elastic limit. Table III shows that within the limits of listed spring indices there is no great effect on the spring torsional elastic limit uncorrected for curvature and shear; however, using the Wahl correction factor gives a different

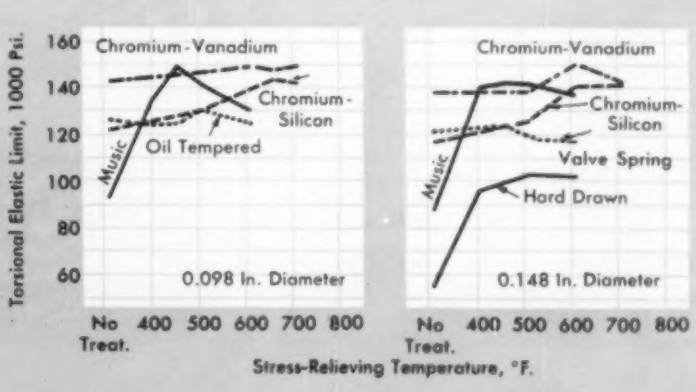


Fig. 5 – Effect of Stress-Relieving on Torsional Elastic Limit of Wire

result. Torsion tests on some stress-relieved wire samples exhibited results similar to those shown for wire tensile tests and spring tests. All show the effects of the varying stress-relieving treatments and the individual values can be correlated with the other test figures. Actual test results are illustrated in Fig. 5.

Table IV – Ratio of Spring Torsional Elastic Limit to Wire Tensile Strength

Type	Ratio for Wire Size			Selected Values
	0.098 In.	0.148 In.	0.250 In.	
Music spring wire	40.7%	45.7%	39.2%	40.0%
Hard drawn spring wire	42.0	44.8	45.2	42.0
Oil tempered spring wire	46.8	48.7	45.0	45.0
Chromium-vanadium	51.7	53.6	50.6	51.0
Chromium-silicon	52.5	53.5	49.5	52.0

Summary

All of the foregoing tables and charts indicate that there is a definite relationship between wire tensile values, wire torsion values, spring torsional elastic limits, and the stress-relieving temperatures. In addition, stress-relieving temperatures for each spring steel (under room temperature and static conditions) necessary to develop the maximum spring torsional elastic limit (spring design stress) are also given. There is a close relationship between the spring torsional elastic limit and the wire tensile and torsional elastic limits. A similar relationship exists between the spring torsional elastic limit and the wire ultimate tensile strength; while this relationship is not so close, the ready availability of wire ultimate tensile strengths makes it essential to use them when predicting the spring torsional elastic limit (spring design stress). Thus Table IV illustrates a working ratio of spring torsional elastic limit (spring design stress) to the ultimate tensile strength of the wire. While there is some spread in the ratios dependent upon wire size, it is felt that the values given in Table IV will be helpful in selecting design stresses and materials for springs.

It must be said that the ratios shown are for *maximum* values and should be used with a safety factor. Further, these figures are for non-set springs under room-temperature and static conditions, and the stresses are not corrected for the effects of curvature and shear; this should also be realized when applying these data.

Figure 6 illustrates design stresses for the spring materials for the full range of manufactured sizes. In this chart we show the spring design stresses based on the ratios in Table IV multiplied by the minimum ultimate tensile strength specified by the American Iron and Steel Institute Manuals, "Carbon Steel Wire, Section 16" and "Alloy Steel Wire, Section 28".

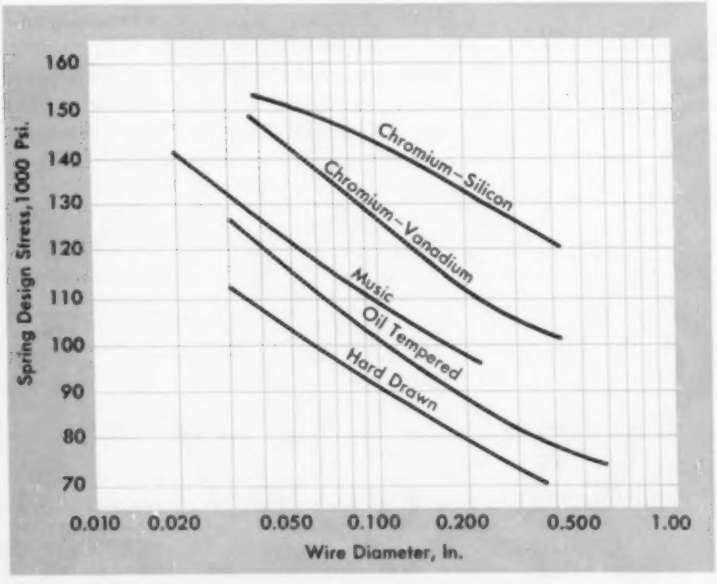


Fig. 6 – Design Stresses for Non-Set Springs. These curves are based on the minimum tensile strength

Semicontinuous Casting of Beryllium Copper

*By K. G. WIKLE**

Billets in large and small size are cast with high yield of sound, fine-grained metal, free from residual beta phase, and at a lower cost per pound than by the conventional Durville process.
(C5q; Cu, *Be*, 4-52)

UP TO 1954 the Durville technique was utilized by the American industry to cast ingots of beryllium copper. Their maximum size was about 250 lb. To produce larger ingots, the Alloy Div. of Brush Beryllium Co. turned to continuous casting and within a year our new equipment was producing rounds and slabs 10 ft. long, up to 75 sq.in. in cross section and 1500 lb. in weight. The quality is such that 1200-lb. coils of 0.090-in. strip have been rolled in continuous mills.

Durville Process – Figure 1 sketches the Durville process – essentially a nonturbulent flow technique in which the casting ladle and the mold are integral. The unit is slowly turned upside down, and the molten metal, at a relatively low casting temperature, is smoothly run into the mold with a minimum of turbulence and oxidation, thus avoiding entrapped oxide, dross and gases. A second advantage is rapid solidification from the low pouring temperature, which minimizes gassing, produces a fine-grained casting, with only a small pipe and cropping loss.

A high-quality casting, sound, clean and fine-grained, is of great importance especially in the 170 and 190 grades of beryllium copper because this much alloy substantially hardens the copper by solid solution. The metal is hot short above about 1500° F. and cold short below about 1200° F. Thus rolling is somewhat difficult even for the highest quality casting. As in more common brasses and bronzes, it is also important that the ingots be free of massive beta structure for good rolling and forging. The real limitation of the method is in the size of ingots; 40 sq.in. cross section and 3 ft. long appears to be the maximum practicable.

Semicontinuous ingots are by no means new in the nonferrous industry. For example, *Metal Progress* in January 1950 described at length the casting of 2000-lb. slabs of brass to feed a new rolling mill of Scovill Mfg. Co., and J. S. Smart, Jr., of American Smelting & Refining Co. described his company's achievements in this line in the October 1955 issue. Schematically, the semicontinuous casting process as used with beryllium-copper alloys is illustrated in Fig. 2. Up to 2000 lb. of molten metal is poured slowly out of the crucible into a clay-graphite tundish wherein any dross carried over has considerable time to rise to the surface. The metal is then under-poured or teemed into an annular copper mold through a graphite nozzle which minimizes turbulence. Since there is always a pool of metal at the top of the casting, an opportunity exists for a final dross separation. Also, this pool continually feeds the solidifying metal below, pro-

*Director of Development, Alloy Div., Brush Beryllium Co., Elmore, Ohio. Three other men are responsible for much of the work leading to the successful process: C. W. Schwenzfeier, vice-president of engineering; J. R. DeJarnett, senior engineer; and J. Kosmo, superintendent in the Alloy Div.

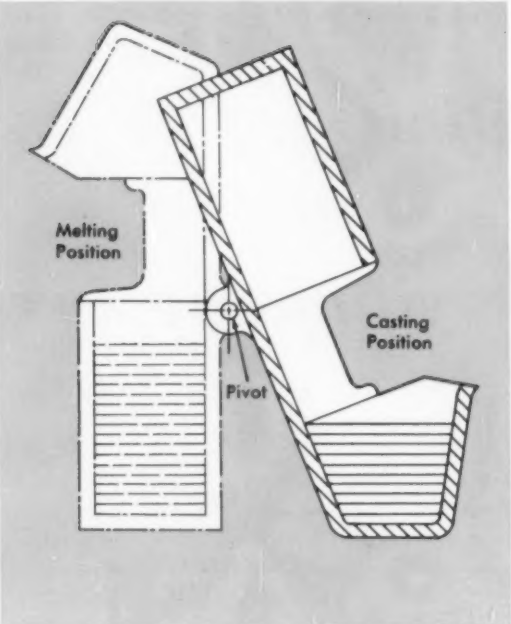


Fig. 1 – Durville Casting Technique

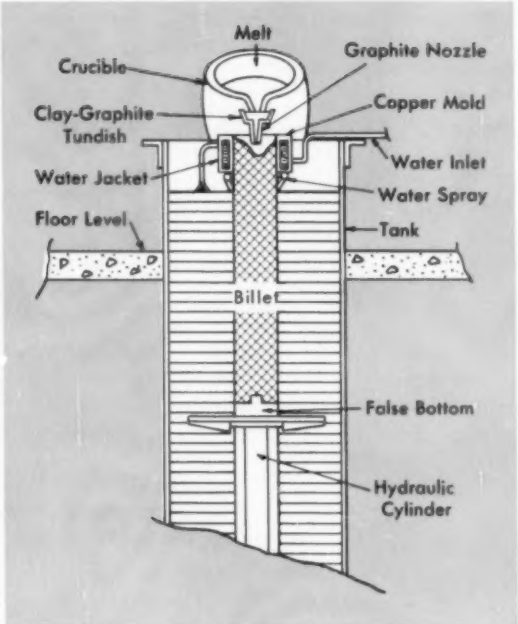


Fig. 2 – Schematic View of Semi-continuous Casting of Beryllium Copper

viding a sound, pipeless casting from bottom to top. A solid product results.

Casting speed is adjustable – about 4 to 6 in. of billet per min.; thus a 10-ft. casting can be made in 20 to 30 min. The water level in the tank, and the flow through the jacketed mold and through the spray, can also be readily controlled. The rate of metal flow is fixed by the orifice in the graphite nozzle, chosen before casting begins and appropriate to the billet size and alloy.

After the billet is cast, the mold is removed, the casting is lifted up and disengaged from the tapered dovetail on the false bottom. It is seldom necessary to crop off more than a few inches from the bottom and top to get into sound metal.

Advantages – The planned and actually realized advantages in the semicontinuous casting technique used at Brush are summarized below:

1. *Uniformity of Casting Conditions.* A large volume of metal is cast relatively slowly; thus the temperature in the holding furnace can be maintained quite constant and delivered to the mold at a uniform temperature where heat is withdrawn at a steady rate over the entire casting cycle, end to end, resulting in uniform structure from bottom to top.

2. *Minimum turbulence and oxidation* result from careful pouring into a metal reservoir from which metal is teemed into the mold below. Turbulence, entrapped oxide, dross and gases are held to a minimum.

3. *Rapid Heat Extraction.* Heat is withdrawn at a high rate, first by a water jacket or spray on the mold, second by a water spray directly on the casting surface just below the mold, and finally by quenching the billet in a tank of circulating water just below the lower spray. Rapid cooling produces a fine-grained structure even in relatively large cross sections. Also, it prevents gas pockets, gravity segregation, and interdendritic shrinkage. The resultant microstructure consists of fine constituents which can be easily homogenized prior to rolling or forging.

4. *Directional Solidification.* Radial solidification begins next to the mold, but as the frozen shell is lowered, solidification changes to a predominantly longitudinal direction. This provides optimum conditions for feeding the metal as it shrinks. Piping is prevented. Dangerous internal stresses are avoided. The surface is usually scalped a depth of 1/16 to ¼ in.

5. *Higher Yields.* Longer castings and little or no piping and cropping losses result in a better yield – less scrap.

6. *Lesser Mold Inventory Costs and Storage Space.* Although the equipment to provide a large and uniform supply of liquid metal and

reliable billet handling may require a larger capital expenditure than for Durville castings, the short sleeve molds are cheaper than large permanent molds, and require far less operating and storage space for a variety of sizes.

7. *Greater productivity* per man-hour is possible, since a larger weight of metal is melted and poured, and the mechanized casting equipment requires only one or two men to operate it.

8. *No Serious Beta Problem.* The presence of residual beta structure (a hard and brittle phase, body-centered cubic, containing about 6% Be and metastable below 1070° F.) in wrought forms of high beryllium-copper alloys is most undesirable. It interferes with cold working, reduces die life, and lowers fatigue and impact properties as well as ductility in the fabricated part. While beta structure is occasionally encountered in Durville castings, it is not to be expected in semicontinuous castings because of their highly chilled structure.

Table I – Nominal Composition and Physical Properties of Semicontinuous Cast Beryllium Copper Alloys

	Alloy 35	Alloy 10	Alloy 165	Alloy 25
Composition				
Beryllium	0.25/0.50	0.45/0.65	1.60/1.80	1.80/2.15
Cobalt	—	2.40/2.60	0.25/0.35	0.25/0.35
Nickel	1.40/1.60	—	—	—
Copper	balance	balance	balance	balance
Specific gravity	8.40	8.75	8.26	8.26
Density, lb. per cu. in.	0.304	0.316	0.298	0.298
Melting range, °F.	1900/2040	1885/1955	1600/1800	1600/1800
Pouring range, °F.	2100/2250	2050/2200	1900/2100	1900/2100
Shrinkage, in. per ft.	3/16	3/16	3/16	3/16
Thermal conductivity*	0.42	0.43	0.25	0.25
Average coefficient of expansion†	9×10^{-6}	10×10^{-6}	9×10^{-6}	9×10^{-6}

*Cgs. units at 20° C. †Per °F., 68 to 392° F.

Melting Practice

Beryllium significantly lowers the melting point of copper and provides a substantial solidification range. Thus, fluidity is increased and feeding is facilitated.

Like aluminum, beryllium provides a somewhat protective oxide film over the melt which diminishes its tendency to dross during meltdown, holding and pouring.

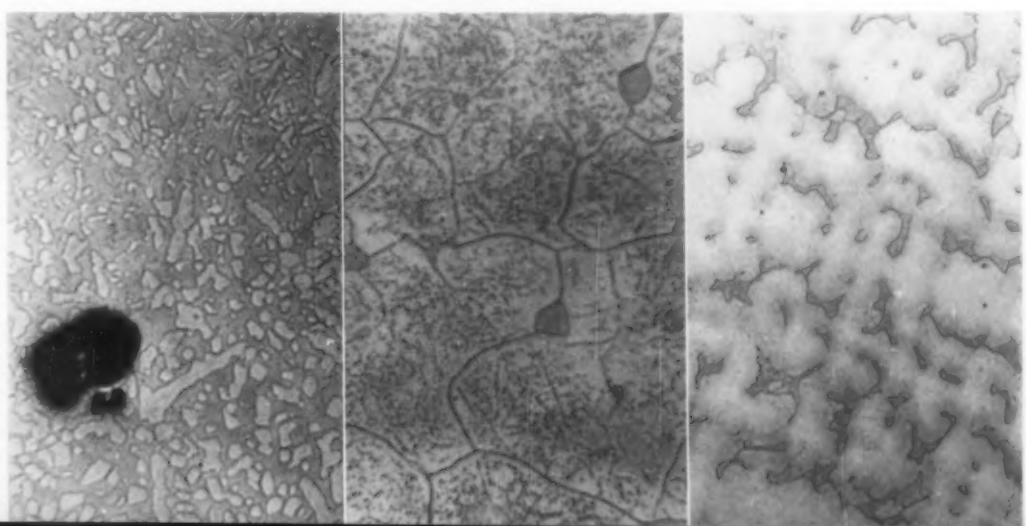
Beryllium is a strong deoxidizer. No significant quantity of oxygen gas exists in the molten bath to cause gassy or oxidized metal. There is no need to use any "deoxidation treatment" before pouring.

Beryllium-copper alloys, such as listed in Table I, are melted with a neutral to slightly oxidizing flame in a gas-fired Fisher furnace. After the charge is melted, covered with fine graphite and brought into the pouring temperature range, the dross is collected, and gas liberated by gently stirring or churning the metal for about 5 min. with a hot carbon or graphite rod. After a settling period of about 10 to 15 min., a shrink pig is poured and when this freezes satisfactorily, the casting operation is started.

Long holding periods are avoided because the

Fig. 3 – Microstructure of Semicontinuous Cast 25 Be-Cu Alloy. Surface is primary beta with alpha islands and porosity. Transition about 0.050 in. deep is essentially alpha with small beta islands. Body of slab is alpha matrix with beta interdendritic phase. All etched in ammonia persulphate

Surface 175 × *Subsurface 750 ×* *Body 175 ×*



melt tends to become gassy and the beryllium content will slowly diminish. In pouring, the shortest ladle-to-mold distance is used to avoid turbulence, thus minimizing oxide films, skins and entrapments.

Billet Structure

In wrought high-strength alloys containing 1.60 to 2.15% Be, freezing begins with the formation of alpha copper dendrites containing beryllium and cobalt in solid solution, and finishes with solidification of interdendritic areas of beryllium-rich beta with a small quantity of cobalt beryllide phase. During subsequent cooling, gamma phase forms by eutectoid transformation of some of the beta and by precipitation from the supersaturated alpha phase.

At the surface of continuous cast material, an inverse segregated structure forms as deep as 0.050 in. This structure, shown at left of Fig. 3, usually consists of a skin of continuous beta phase which changes through a phase which is essentially 100% alpha (center micro) and then to the normal structure consisting of continuous alpha phase containing distributed beta (Fig. 3, right).

Inverse segregation at the surface is caused by a series of events: First, a metal skin is drastically cooled by contact with the copper mold. A solid shell of alpha copper immediately forms and contracts away from the mold wall, but is immediately reheated by the molten metal in the interior. Thermal expansion and hydrostatic pressure expand it into contact with the cold mold wall. After several such cycles, the thickness of the freezing shell becomes great enough to resist further cyclic movement, but the more fusible beta phase in the surface region has been squeezed out to the surface through interdendritic passageways in the frozen alpha phase and the skin of high beta content is built up. This layer is hard, brittle, hot short and frequently somewhat porous, so it must be scalped before rolling, forging or extrusion.

Beneath the surface of rapidly cooled fine-grained castings, the beta phase and the cobalt beryllides exist as well-distributed small particles. If the pouring temperature is too high or the cooling rate is too low, a coarse-grained casting may result, containing undesirable massive beta, and the metal may be unduly hot short.

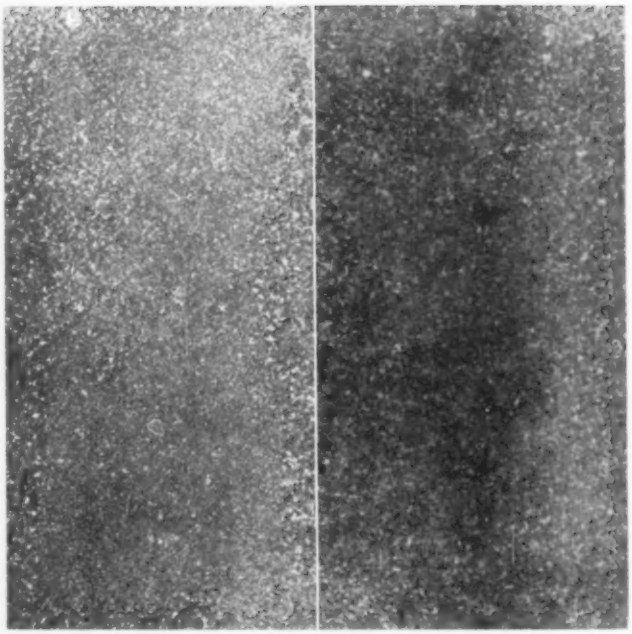


Fig. 4 – Small Equiaxed Grains in Both Transverse Cross Section (Left) and Typical Longitudinal Section (Right) of 4 × 8-in. Billet of Be-Cu, Semicontinuously Cast. About half size

Macrostructure – A proper combination of low pouring temperature and fast cooling will give fine-grained equiaxed structures. Figure 4 shows both cross-sectional and longitudinal macrostructure of a 4 × 8-in. semicontinuous billet. Note the thin layer described above (at the very surface) and the fine equiaxed structure even in the longitudinal section.

In comparison, a longitudinal section of a similar casting with the structure made deliberately coarse by a high pouring temperature and a slow cooling rate is illustrated in Fig. 5. It has a columnar grain structure oriented up about 45°. Thus, when casting conditions are controlled carefully, a fine-grained structure is obtained which provides a dense structure with minimum internal stresses, favorable for subsequent fabrication.

Rolling – After casting, the billets are cropped a few inches off both ends to remove unsound material. The bottom of the billet is formed by pouring the metal into a relatively cold mold and under essentially static conditions; the top does not benefit from a continuous reservoir of molten metal to feed it as freezing occurs.

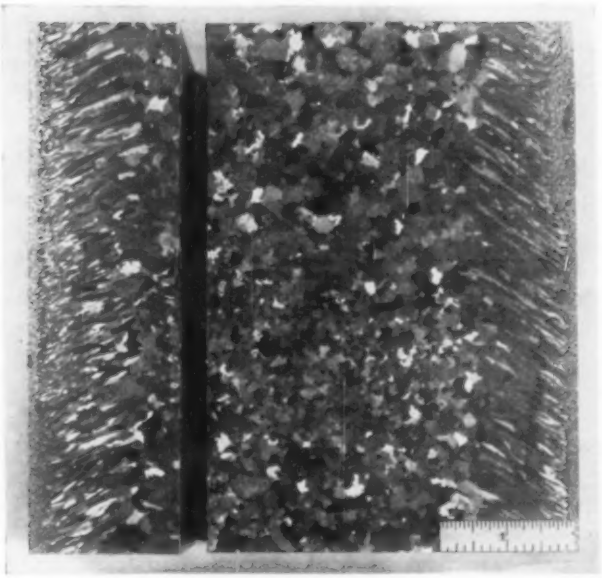


Fig. 5—Longitudinal Sections of 4 × 10-in. Billet Poured Too Hot and Cooled Too Slowly. Half-section in 4-in. direction at left, in 10-in. direction at right. Note columnar grains near surface and coarse grains in center

After cropping, approximately ¼ in. is scalped from the surface to remove the inversely segregated layer. Billets are then either "dy-checked" or macro-etched to discover porous areas; if any are found, they are removed by grinding.

High-strength alloy billets are soaked 8 hr. or more at 1450 to 1475° F. to homogenize the cast structure. Hot rolling is in the 1475 to 1200° F. range. (These alloys are hot short above 1500° F. and cold short below 1200° F.) Hot rolling of plate, sheet and strip has been carried out in the Brush rolling mill facilities. A 1000 to 1200-lb. billet can be reduced to coils of the same weight in a production steel strip mill having a 3-high roughing mill and a tandem line of five 4-high finishing stands. Nine passes in a 3-high roughing mill bring a 4-in. slab down to ½-in. bar, which is then run down to 0.090-in. strip in the tandem line and coiled while still hot. Time required is about 1½ to 2 min. After solution annealing at 1450° F. and pickling to remove the black scale, the coil is ready for cold rolling down to light gages.

Forging – Billets of the alloy noted in Table I are readily forged into various shapes with high strength and toughness. The high-conductivity alloys No. 35 and 10 are forged, after soaking at 1650 to 1700° F., into such items as seam welding disks and resistance welding dies and electrodes. The high-strength alloys are forged, after soaking at 1450 to 1475° F., into such parts as safety tools, bushings and other mechanical parts.

These alloys may be heated in coke, gas, oil or electric furnaces. They are quite plastic and can be readily deformed with conventional forging technique. The hot working range for both types of alloys extends down only to 1200° F., so forging periods are short compared to steel. Consequently, billets after an initial easy breakdown of the cast structure must be severely worked to maintain temperature. As the metal cools, lighter blows must be delivered.

After forging is complete, parts may be cooled at any convenient rate. Parts must then be solution annealed and age hardened to develop the highest properties.

Extrusion is done in a temperature range similar to rolling and forging – that is, 1700 to 1200° F. for No. 35 and 10 alloys and 1475 to 1200° F. for No. 165 and 25 alloys. Temperature about 50° under the top of the range is recommended for the billet. In comparison with other copper-base alloys, the 165 and 25 alloys, because of the lower working range and the strengthening effect of beryllium, require higher pressures and better lubrication. Die life is also shorter.

Extruded rod is stock for small forgings, wire-drawing and machined parts. Extruded No. 35 and 10 alloy rod is used in substantial quantities for resistance welding electrodes. Beryllium-copper wire is widely employed as compression, extention and torsion springs where good fatigue properties coupled with good conductivity, corrosion resistance or nonmagnetic characteristics may be desired. Tubular extrusions are cold drawn into thin walled tubes.

Summary

Since 1954 the Brush Beryllium Co. has been furnishing a new form of alloy casting for wrought products – namely, a semicontinuous cast billet. It can be five times heavier than those previously available, and has excellent metallurgical qualities. It can be more economically processed into strip, forgings, bar, rod and extrusions in high-production equipment with minimum scrap.

Stress-Free Nickel Plating

STAFF REPORT

Nickel in stress-free condition or with compressive stress can be plated from a sulphamate bath. It is finding a number of engineering applications on parts plated to improve fatigue life and minimize fretting and wear, and in electroforming to avoid distortion. It holds promise for improved high-temperature coatings for missiles and rockets. (L17a, Q25; *Ni*)

A MYSTERIOUS, yet significant, property of nickel electroplates is that they are formed in a condition of internal contractile (tensile) stress unless specific organic addition agents are present or unless one type of electrolyte is used. Stresses may reach 30,000 to 45,000 psi. in plates from the widely used Watts-type solution. These stresses can interfere with the use of nickel plating in a number of engineering applications. Peeling, cracking, crazing, warping, blistering, distortion, shrinkage and even complete failure of plated metals either as structural units or protective coatings can result.

Early in 1947, Richard C. Barrett started research to find a nickel-plating bath which would give deposits low in stress without the use of organic addition agents. Hundreds of stress measurements were made using over 1500 nickel-plating baths during a two-year period. The only bath which showed a pronounced decrease in stress was based on nickel sulphamate. At a Symposium on Nickel Plating held by the Cleveland Branch of the American Electroplaters' Society, Mr. Barrett discussed the increasing commercial applications for the sulphamate nickel plating system, now being handled by the Barrett Chemical Products Co., Inc., Shelton, Conn., of which he is president. More than a quarter-million gallons of the sulphamate bath are now in use in the United States and in a number of foreign countries.

Chemical Composition

Sulphamic acid (HSO_3NH_2) is a strong monobasic acid (made by the Du Pont Co.). It will react with metals, metal oxides or metal carbonates to give the corresponding metal sulphamate. Nickel sulphamate [$Ni(NH_2SO_3)_2$] prepared by reacting a solution of the acid with nickel carbonate is so soluble that it cannot be easily recrystallized from solution. The solubility is many times that of single nickel salts or nickel chloride. This makes it possible to build electrolytes with exceptionally high metal content — a desirable condition for high current density operation.

The basic composition for a general-purpose sulphamate plating bath which will deposit nickel of medium hardness (Vickers 250 to 350) at low internal stress is given below:

Nickel sulphamate	60 oz. per gal.
Nickel metal content	10.2
Boric acid	4
Antipit agent	0.05

The average mechanical properties of nickel deposited from this solution are: elongation in 2 in., 20 to 30%; tensile strength, 90,000 psi.; internal tensile stress, 0 to 500 psi.

The plating solution may be prepared from available concentrates of nickel sulphamate by dilution to the right concentration and purification. The wetting agent and boric acid are added and the pH is adjusted to the correct range by careful additions of sulphamic acid. The solution is also available in a purified ready-to-operate condition. The bath is generally operated at pH 3 to 5 in the range 100 to 140° F. Maximum cathode current density is 300 amp. per sq.ft. at 140° F. Method of agitation can be cathode bar movement or solution circulation. Both anode and cathode efficiency attain a value close to 100%.

With slight modification of solution or operating conditions and with the use of addition agents, the sulphamate bath can be adjusted to give deposits with properties to meet any special requirements. Hardness of the plate may be increased to Vickers 550 – which approaches the lower range of hard chromium plate. Stress in the compressive range can be produced, which is important in minimizing fatigue failure. Tensile strength of the deposit can be increased with little difficulty.

Stress Control

The primary advantage of the sulphamate plating system and the one characteristic that justifies it in most applications is the ability to regulate stress in the deposit and thus control a variety of side reactions which undesirable stress conditions may cause. (Where stress must be kept under close production control, some type of stress measuring instrument, such as the Brenner-Senderoff Spiral Contractometer, should be used every day.)

With electroplating getting more important as an engineering tool to solve production problems, stress control takes on more significance. For example, electroforming is being used to make wave guides, optical diffraction gratings, plastic molds and molds for items such as plastic boots. These are applications where no distortion can be permitted. Worn or mismachined parts are being salvaged by heavy nickel plate. Here the deposit must be tensile-free so as not to harm the fatigue properties of the underlying steel. Fatigue fractures do not originate and cracks cannot propagate in compressively stressed materials; however, tensile stressed surfaces as thin as 0.0003 in. can be a serious threat to early failure. Heavy nickel plate under compression is being used to increase fatigue life by protecting surfaces from nicks and scratches which might lead to fatigue failure. Two examples are the protection of the leading edges of propeller blades and jet engine compressor blades from small stone abrasions.

Fig. 1 – Richard C. Barrett, Who Developed the Sulphamate Bath for Stress-Free Nickel Plating, Shows a Variety of Plated Parts Where Stress Control Is Important. Included are an electroformed mold for plastic boots, jet engine compressor blades and other aircraft parts, printed circuits, electronic contacts, switches and phonograph record stampers. (Courtesy E. I. du Pont de Nemours & Co., Inc.)

In electronics, stress-free nickel is important as an undercoat for gold and rhodium in printed circuitry. A stressed nickel plate will lift the original copper-base circuits off the boards since the bond is only a light one at best. In some cases, a compressively stressed sulphamate nickel deposit is used to offset the high tensile stress of rhodium plating.

Hard, but ductile, sulphamate nickel deposits are replacing soft silver plate on contact pins and jack terminals of electronic equipment. The good throwing power of the sulphamate solution, and the ability to operate at high current densities with relatively low temperature makes it ideal for barrel plating intricate small parts such as these. The high purity of the nickel deposit

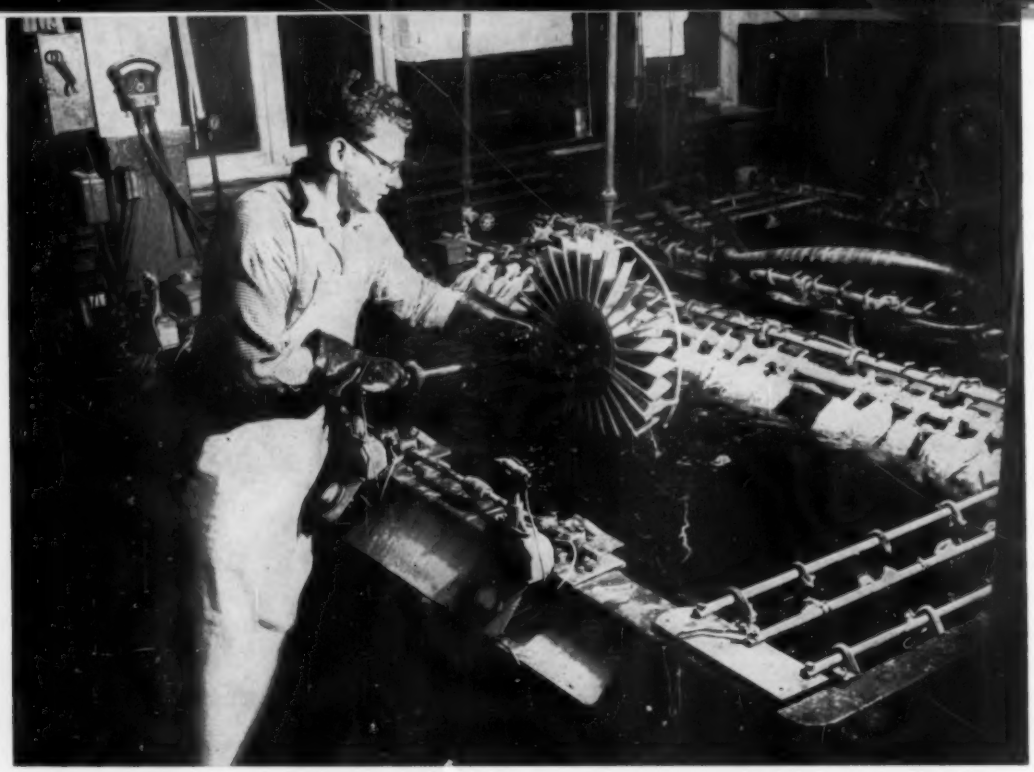


Fig. 2 – Heavy Hard Nickel Plate With Compressive Stress Is Applied to This Aluminum Inducer for a Jet Engine. Fatigue life is improved by protecting the leading edge from nicks, scratches or dents. (Courtesy E. I. du Pont de Nemours & Co., Inc.)

from the sulphamate system gives it unusual magnetic activity. Alloy deposits of nickel with cobalt and iron are finding magnetic applications in such parts as memory drums for electronic computers.

Stress-free or compressively stressed nickel plated from sulphamate solutions is being used to prevent fretting on tightly fitted aircraft parts subject to vibration. In some cases this has eliminated the need for shot peening to get a compressively stressed surface. It avoids the reduction in surface finish which is normal to a peening operation. On some parts a distinct reduction in surface roughness is being realized by plating compressively stressed hard nickel. At the same time, fretting and its corrosion by-product are eliminated.

Electroplating stereotypes with nickel greatly improves corrosion and wear resistance and enhances other physical properties. Press runs of over one million impressions are becoming standard practice.

High-Temperature Applications

Tests have shown that stress-free sulphamate nickel deposits undergo less dimensional and density changes from heat treating than stressed deposits from a Watts-type solution. The lower porosity of the denser electroplate has a big advantage in protecting active metals from superficial oxidation. This property is being studied for application to aircraft, missile and rocket construction materials.

Sulphamate nickel deposits have been given extreme thermal shock tests by heating to 2300° F. in a few seconds using a solar furnace, then rapidly quenching to ambient temperatures. There was no damage to grain structure, and no intergranular expansion (with subsequent breakdown) occurred as did with nickel deposited from conventional solutions.

Diffusion coatings of nickel-cadmium and nickel-chromium are being investigated for high-temperature and corrosion applications. They appear to have less porosity when sulphamate nickel is used because of higher density and lower inclusions in the nickel phase of the diffusion alloy. Stress also has an effect on the bond strength – large stress can cause the coating to separate from the base metal before diffusion takes place.

As for the future of engineering applications for stress-free nickel plating, Mr. Barrett has this to say: "Every day brings to our attention some distinctly new use for the sulphamate plating system which is completely dependent on its ability to deposit nickel with low stress."

Metallurgy of Tempering and Annealing in Fractional Minutes

*By R. K. WUERFEL**

Conditions for annealing nonferrous metals and tempering steels can be put on master curves. Tests were made to show that the optimum time for annealing or tempering by fractional-minute induction heating can be calculated. (J2g, J23, J29, 3-67)

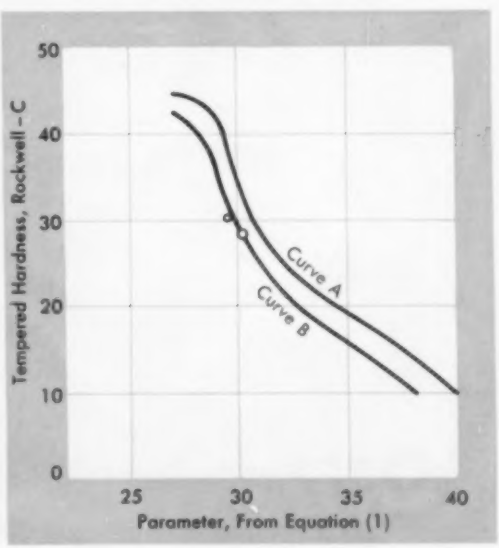
ANNEALING AND TEMPERING cycles which once took hours are now being carried out in less than a minute. The demand by industry for more short heating cycles requires a better understanding of the metallurgy involved. Master curves offer help because they can be used to calculate fractional-minute tempering and annealing times.

This study will deal mostly with hardness – particularly the hardness of tempered Type 410 stainless steel. The same principles apply to annealing any metal for grain size or hardness.

In 1946, Hollomon and Jaffe (*Transactions*, A.I.M.E., Vol 166, 1945, p. 223) published their hardness, time, and temperature relationship. In 1950, Nehrenberg (*Steel*, Oct. 23, 1950) simplified their presentation from three variables to two – hardness and a dimensionless parameter. Nehrenberg called this a master curve. Since 1950, Nehrenberg's approach has been successfully applied to metallurgical reactions in creep, grain size, annealing, and tempering.

The master curves of Larson and Salmas (● *Transactions*, Vol. 46, 1954, p. 1377) are good guides for annealing a great variety of metals. Those of Grange and Baughman (● *Transactions*, Vol. 48, 1956, p. 165) are also helpful in tempering steels.

Fig. 1 – Master Curves for Tempering Type 410 Stainless Steel



*Metallurgist, Industrial Electronics Dept., Westinghouse Electric Corp., Baltimore, Md. This paper was prepared at the request of the Industrial Heating Equipment Assoc. and presented at the I.H.E.A. meeting during the ● National Metal Congress, Chicago.

Figure 1 shows two master curves for Type 410 stainless steel. Curve A is Nehrenberg's; curve B is for the heat of steel used in this study.

The master curve is a plot of a physical property versus a dimensionless parameter. This parameter consists of an infinite number of time and temperature combinations. In Fig. 1, we see that higher parameters correspond to more tempering, lower parameters to less tempering.

The parameter equation for furnace and salt bath heating is given below:

$$P = (^{\circ}F + 460)\ (20 + \log_{10} T_h) \times 10^{-3} \quad [1]$$

P is the parameter, °F is the temperature to which the material was heated, and T_h denotes hours at heat. It is apparent that the same parameter can be produced in two ways – low temperature with long time, or high temperature with short time. In either short or long heating, there are metallurgical limits. These are exaggerated grains or temper embrittlement at long heat times, phase changes or melting at short heat times.

Now we come to the main problem in this study: Can time in the parameter equation be extended to include short heat times encountered in induction heating? This question was tested on a tough job – induction tempering of Type 410 stainless steel.

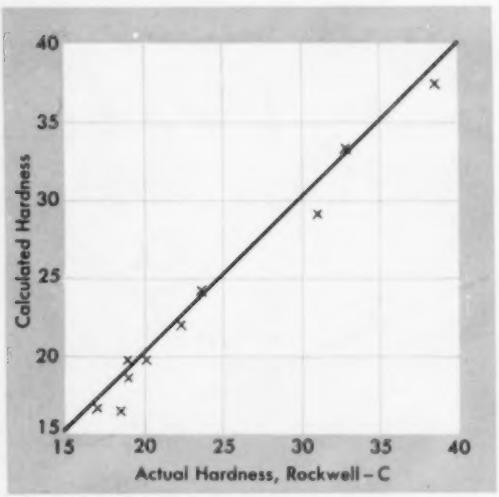


Fig. 2 – Comparison of Actual With Calculated Hardness for Type 410 Stainless Steel, Tempered by Induction Heating

Fig. 3 – This Induction Annealer Can Process 22,000 Brass Cartridge Cases Per Hr. Using 30 Kw. of 10-Kc. Power. (Courtesy Westinghouse Electric Corp.)

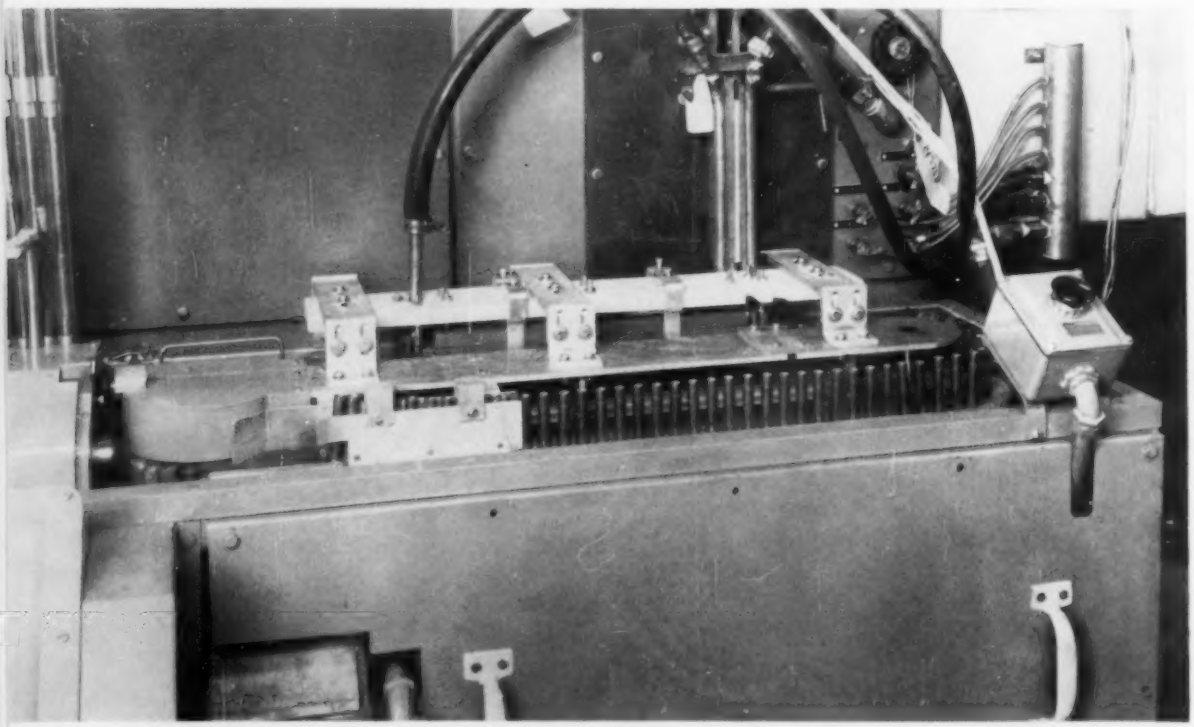


Table I – Results of Tests on Furnace Tempering of Type 410 Stainless Steel

Test	Temp.	Time	Parameter	Hardness
1	1100° F.	8.0 hr.	32.6	C-19.5
2	1135	4.0	32.8	20.0
3	975	4.0	29.5	30.5
4	1005	4.0	30.2	28.7

Table II – Results of Tests on Induction Tempering of Type 410 Stainless Steel

Sample No.	Maximum Temperature	Heat Time	Rockwell Hardness
1	1140° F.	30.1 sec.	C-38.5
2	1220	30.0	31.0
3	1330	30.0	22.3
4	1425	30.0	19.0
5	1120	108.6	33.0
6	1235	108.6	24.0
7	1330	108.3	20.0
8	1435	108.0	18.5
9	1330	108.0	19.0
10	1430	108.0	17.0

Experimental Results

To make the comparison of furnace and induction tempering, a series of Type 410 stainless steel bars was oil quenched from 1850° F. and divided into two groups: those to be furnace tempered and ones to be induction tempered. Four samples were furnace tempered. These results are given in Table I and the master curve is in Fig. 1. Curve B is parallel to curve A, but somewhat lower. This is expected from the analyses of the two heats given below:

	Heat A	Heat B
C	0.12%	0.10%
Mn	0.45	0.34
Si	0.35	0.22
Ni	0.48	0.21
Cr	12.51	12.05
Mo	0.09	0.06

The induction tempered samples were 1 1/32-in. rounds, 4 in. long, heated at a frequency of 960 cycles. The heat cycle was recorded by a high-speed recorder. The thermocouple was placed ⅛-in. below the surface and hardnesses were measured at this depth. The hardness throughout most samples was within two points Rockwell C. The greatest variation occurred on the lowest parameter samples. They varied as much as four points. Hardnesses are the average of four tests taken ⅛ in. below the surface.

Sample 4 (Table II) was heated to 1425° F. in 30 sec. It tempered to C-19.0. In Table I, we see that a furnace temper at 1100° F. required 8.0 hr. to produce C-19.5. This is a difference of 7 hr. and 59.5 min. process time.

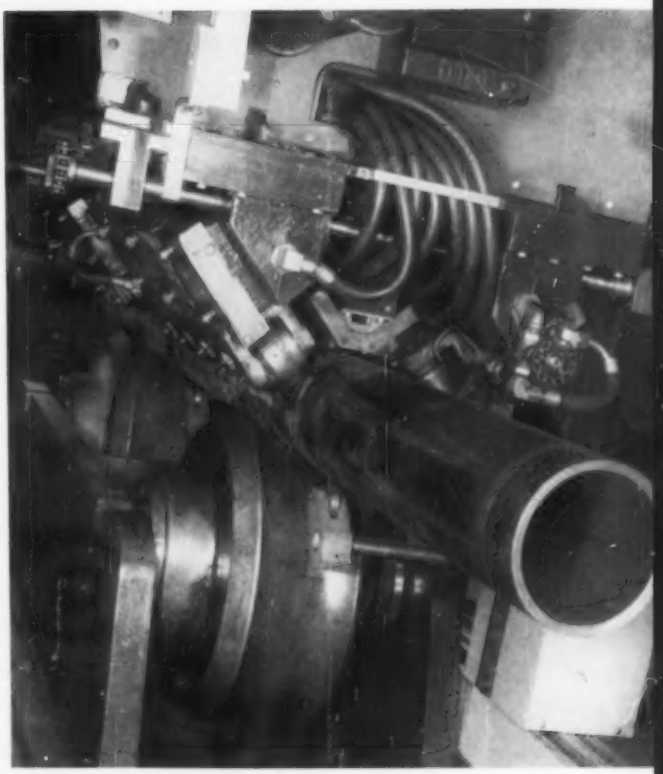


Fig. 4 – Steel Pipe Is Annealed Continuously at a Speed of 60 In. Per Min. by This Machine. It's rated at 300 kw. of 3-kc. power. (Courtesy of Ohio Crankshaft Co.)

Calculated Hardness Values

The logarithms of numbers from 0 to 1 are negative. Since all of the induction heating cycles had heating times less than 1 hr., they all appear as negative logarithms in Equation [1]. The time portion of Equation [1] was changed from hours to seconds, as shown below, to eliminate negative logarithms before comparing furnace and induction results.

$$20 + \log_{10} T_h = 16.44 + \log_{10} T_s$$

The parameter equation for heat times in seconds then is:

$$P = (°F + 460)\ (16.44 + \log_{10} T_s) \times 10^{-3} \quad [2]$$

In using Equation [2] for induction heating, temperature is the maximum (°F) to which the area was heated in seconds (T_s) of heating time. The parameter corresponding to each induction

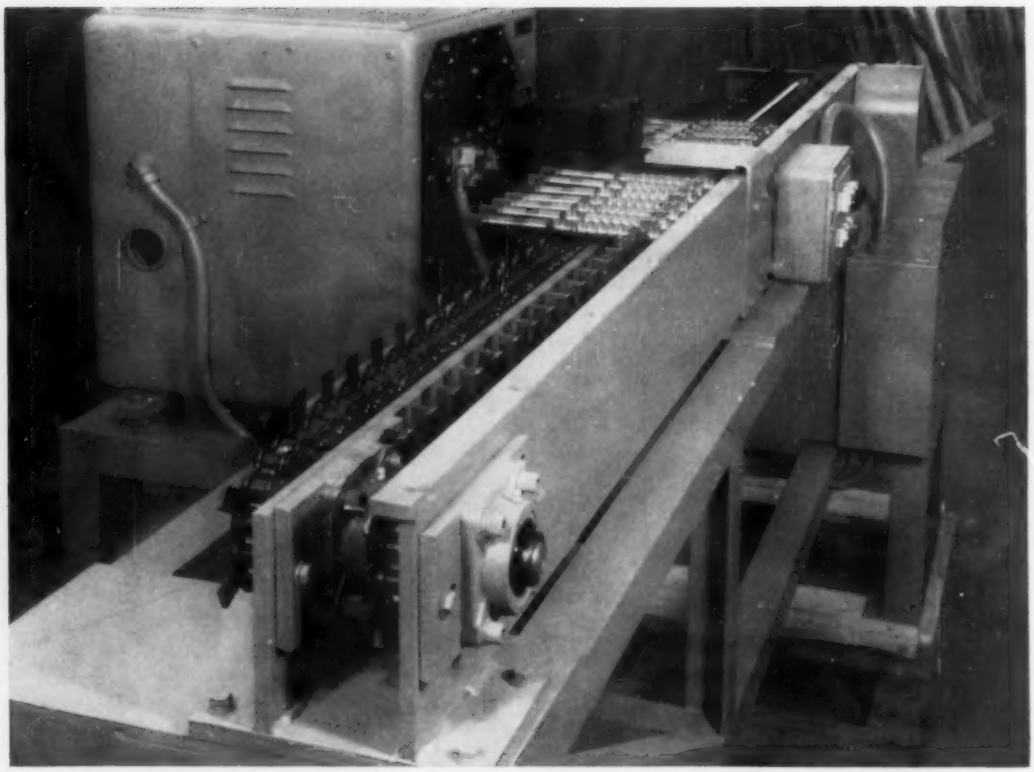


Fig. 5 – This Annealer for Ends of Steel Bars Produces 210 Pieces Per Hr. in Continuous Operation With 25 Kw. of 10-Kc. Power. (Courtesy Ohio Crankshaft Co.)

tempering cycle was determined and the corresponding predicted tempered hardness taken from curve B, Fig. 1. Table III compares the test results with the values calculated by use of the revised equation.

The following example shows how the calculated hardness was determined: From the first line of Table III, the temperature, 1140° F., and the time, 30.1 sec., are put into Equation [2]. The resulting parameter is 28.7. The tempered hardness which corresponds to a parameter of 28.7 on the master curve B in Fig. 1 is 37.2. This is the calculated hardness.

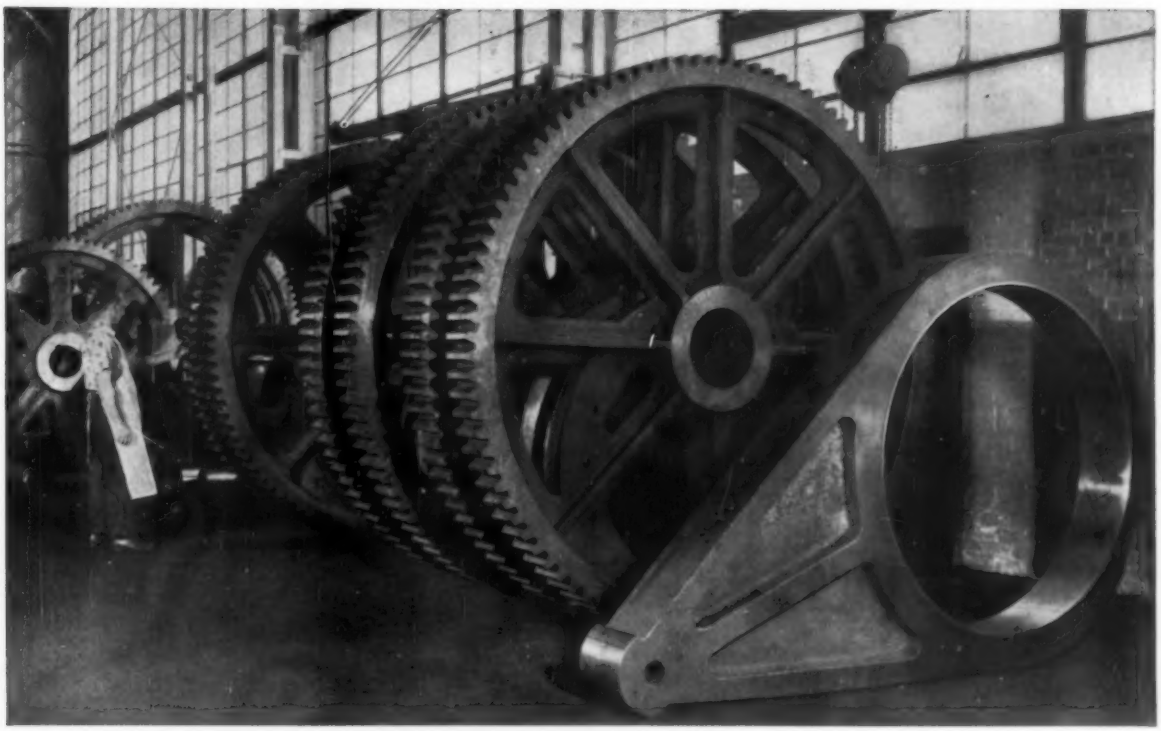
Figure 2 plots actual and calculated tempered hardnesses given in Table III. The 45° line is in good agreement and the comparison points show satisfactory relationship. Two conclusions can be made: *(a)* The tempered hardness of Type 410 stainless can be calculated from a master curve; *(b)* Equation [2] can be applied to induction cycles which are as short as 30 sec.

Table III – Comparison of Actual With Calculated Tempered Hardnesses for Type 410 Stainless Steel

Temperature	Time	Rockwell Hardness		
		Actual	Calculated	Difference
1140° F.	30.1 sec.	C-38.5	C-37.2	−1.3
1220	30.0	31.0	29.0	−2.0
1330	30.0	22.3	22.0	−0.3
1425	30.0	19.0	18.5	−0.5
1120	108.6	33.0	33.3	0.3
1235	108.6	24.0	24.0	0.0
1330	108.3	20.0	19.7	−0.3
1435	108.0	18.5	16.4	−2.1
1330	108.0	19.0	19.5	0.5
1430	108.0	17.0	16.7	−0.3

Summary

The knowledge of annealing nonferrous metals and the tempering of steels can be put down on master curves. The tests reported here show that the optimum induction heat time for any annealing or tempering application can be calculated.



Dynamically stressed parts for 2000-ton "tryout" press...

Made of ductile cast iron, for superior strength, needed wear resistance

These large gears and connecting rod are used in a 2000-ton mechanical "tryout" press. In discussing his choice of ductile iron for these critical parts, Stewart Cumming, the designer – had this to say:

"We have for years favored cast iron for gear teeth and eccentrics because of its good wearing properties in bearing surfaces, but in some cases were forced to use either steel castings or weldments in order to obtain the necessary strength.

"The development of ductile iron enabled us to use this material to advantage, by providing the strength required for gear teeth without sacrificing good wearing surfaces on tooth faces.

"In the intermediate spur tooth gears and high speed herringbone gears of these large presses, good tooth-bearing surface qualities are particularly important. These gears are subjected to heavy stresses in clutching and braking.

"The use of ductile iron enabled the eccentric strap portion of the connecting rods to be held to as small a cross section as would be possible with steel – a distinct advantage in gaining operating clearances. The knuckle joint end, which is subject to high bearing loads at the time of impact, has better wearing properties in a bearing surface than could have been attained with an unheat-treated steel."

2000-ton "tryout" press (shown forming auto fenders) can handle most large dies or group of dies. Built by Federal Engineering Company, Detroit, a major builder of machinery, dies and tools, and designed by Stewart Cumming & Son, Ferndale, Michigan (engineers in the same line) with ductile iron in key operating parts.

More ductile iron advantages...

Other designers report additional ductile iron advantages for gears: excellent machinability, high damping capacity, and good castability. Surface hardening techniques can usually be used, too, to increase hardness to 600 BHN.

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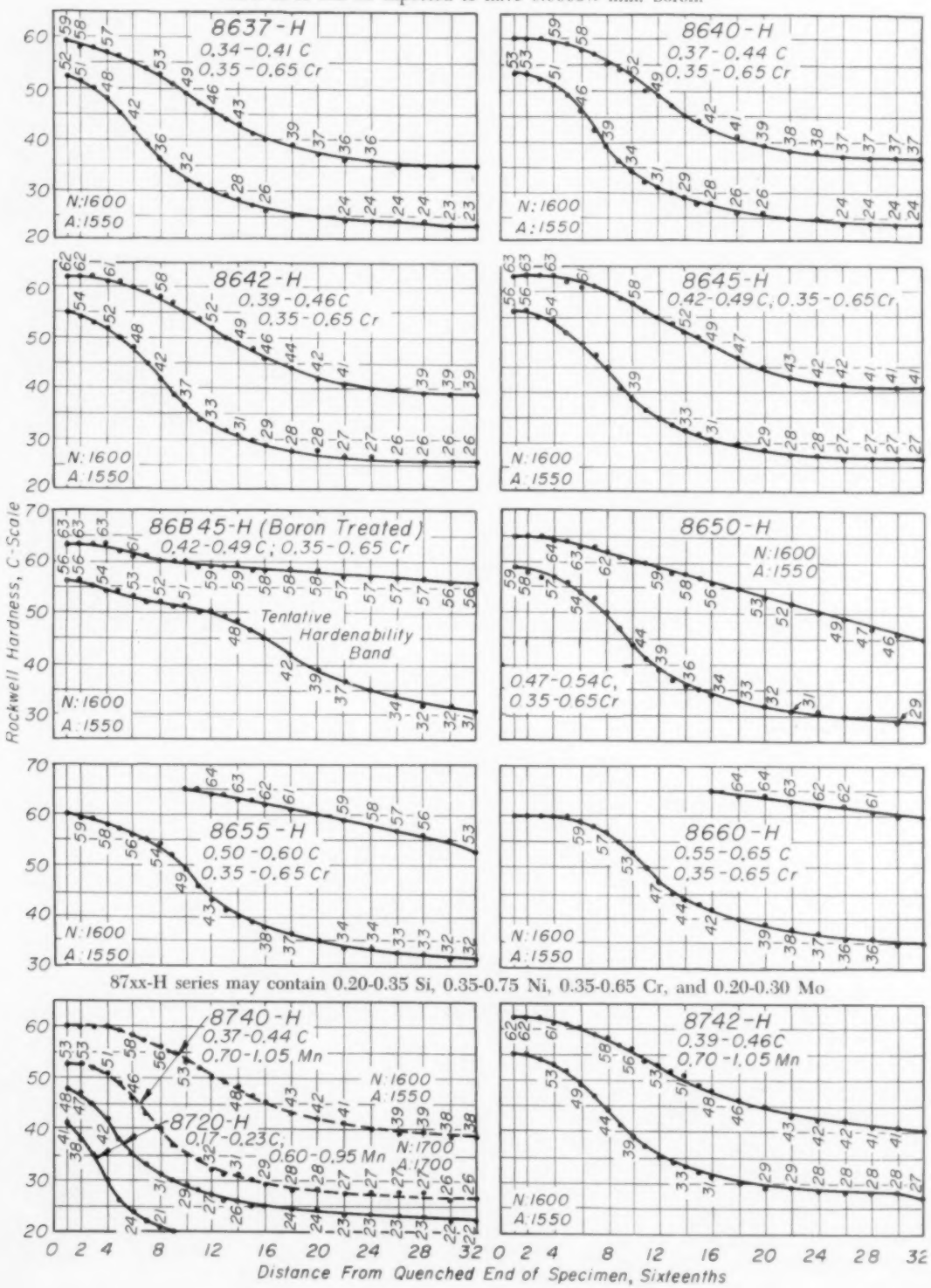
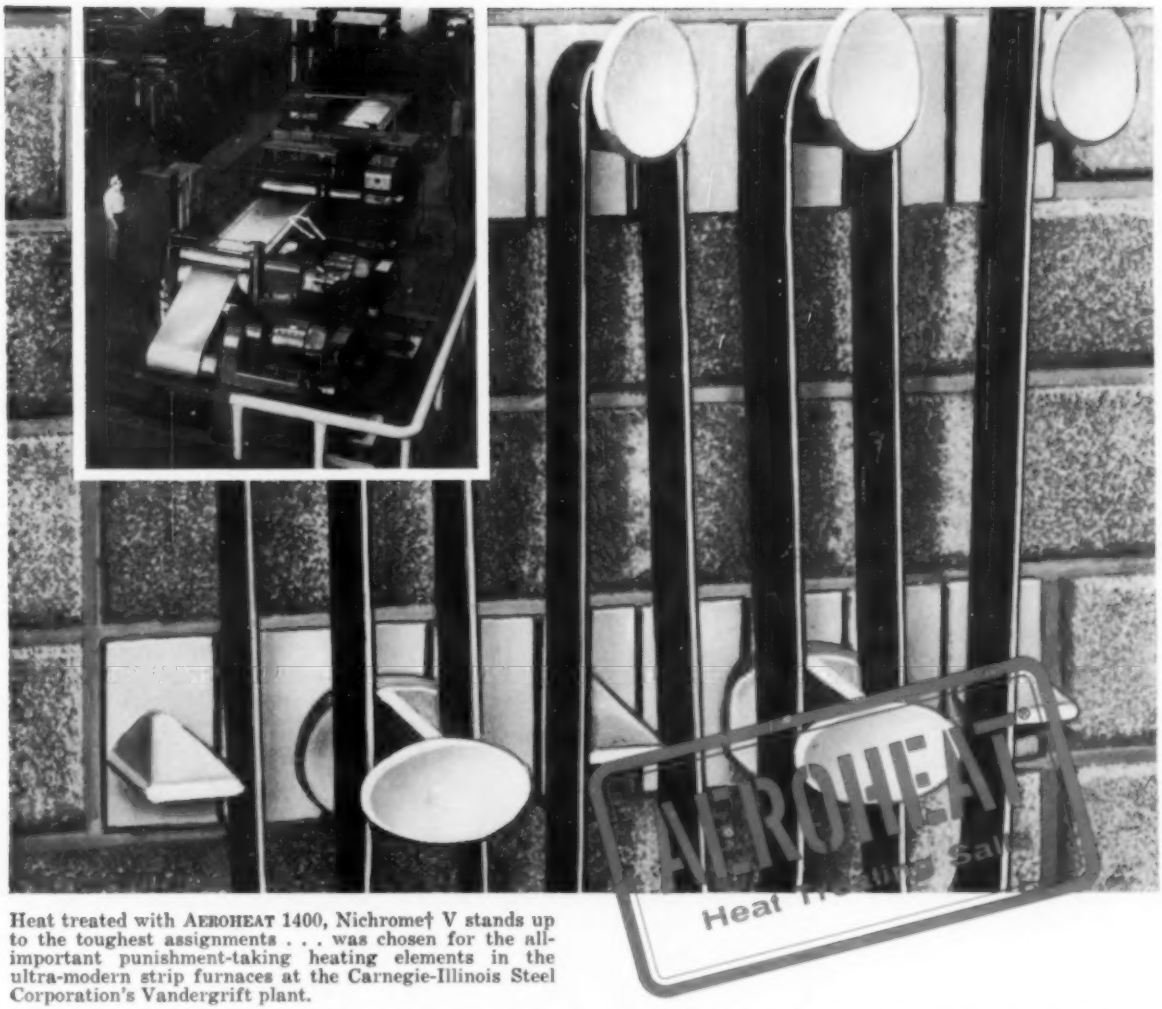
86 B 45-H can be expected to have 0.0005% min. boron.



87xx-H series may contain 0.20-0.35 Si, 0.35-0.75 Ni, 0.35-0.65 Cr, and 0.20-0.30 Mo



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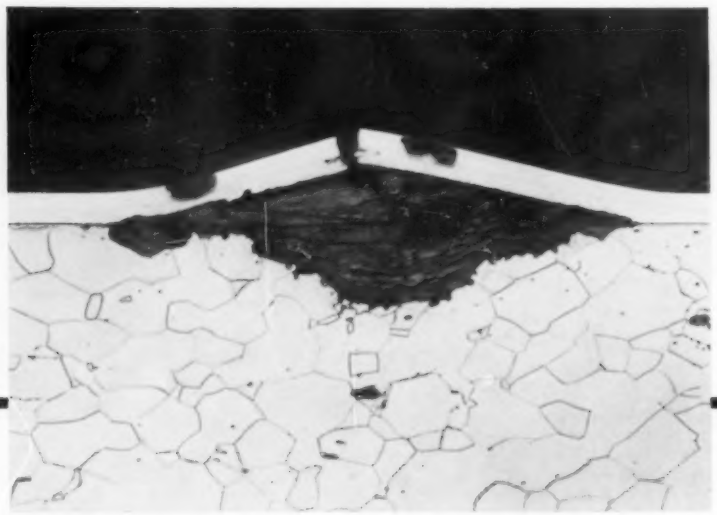

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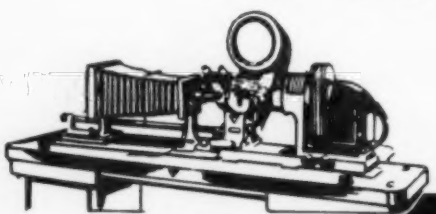

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Zone Melting Opens New Horizons in Metallurgy

*STAFF REPORT**

Zone melting is fast developing into an important method for metal purification. It also has other uses in research, development and manufacturing. For example, it can distribute an impurity uniformly throughout a single crystal – a problem long unsolved. Purpose of this article is to tell what can be done with zone melting, not precisely how to do it. (C28k)

THE PRIME REASON for recommending zone melting to metallurgists – whether they are engaged in research, development or manufacturing – is that it can purify metals. The metallurgist has long been aware of the significance of high purity in metals; he is familiar with the striking effect of minute amounts of certain foreign elements.

He also knows that the tools and standards of measurement of solid state physics have become keener in recent years; for some applications, users are no longer satisfied with the pure metals of a decade ago. The field of nuclear fission is one example: Impurities long regarded as innocuous are now found to be intolerable because of their neutron absorption properties or because of undesired radioactivity induced in them during irradiation of the parent metal. Another example is the realization that impurities, by their interaction with dislocations, are intimately involved in the plastic deformation and recovery processes that nearly all commercial metals undergo at some time in their life.

While these examples come largely from metals research, it will follow, as it always has, that sooner or later the metal producer will be confronted with a demand for purer metals arising from practical applications of today's fundamental studies.

Zone melting has important uses other than purification. It can distribute a desired impurity uniformly throughout a single crystal – a problem long unsolved. It can produce precisely controlled discontinuities in impurity concentration, such as the p-n or n-p-n junction in semiconductors, which comprise the basic building blocks of transistors and solid diodes. It can do diverse jobs, such as joining, and can be used to measure diffusivities in liquids. In short, zone melting is a powerful new tool for manipulating impurities in crystals.

The first important application of zone melting was to purify germanium for use in transistors (Fig. 1). Its success here was so spectacular that in short order it was widely adopted by transistor and diode manufacturers in America and Europe.

If this were the only practical application, the method might still be noteworthy. However, zone melting can be applied to many other materials. It works with any crystalline substance that can safely be melted, which exhibits a difference in impurity concentration between

*Adapted in large part from the forthcoming book, "Zone Melting", by W. G. Pfann, Bell Telephone Laboratories Inc., Murray Hill, N. J., which will be published this month by John Wiley & Sons, New York.

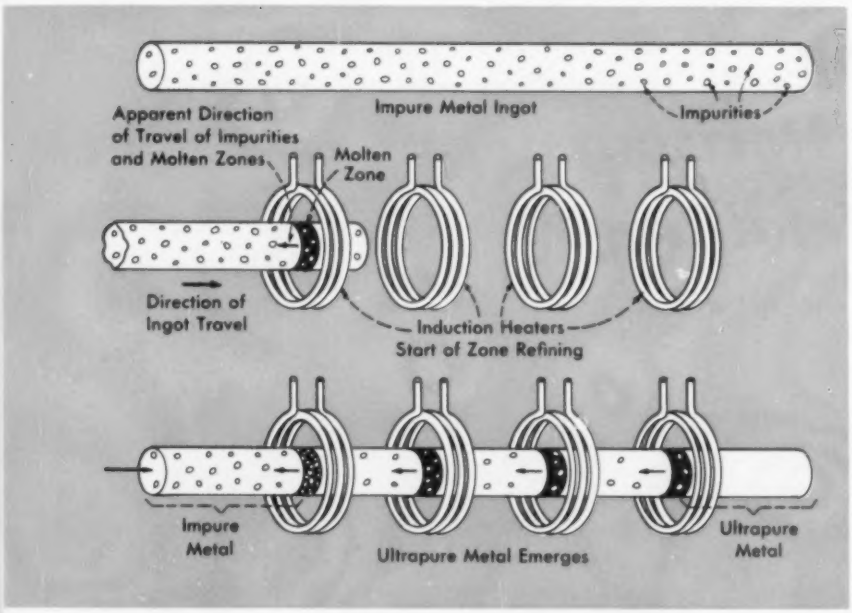


Fig. 1 – Technique for Zone Refining. As the molten zones travel through the ingot, each carries a fraction of the impurities toward the end of the ingot, leaving the purified material in the remainder. The method has been widely used for germanium, other semiconductors, and metals

liquid and freezing solid. It's not surprising, then, that zone melting is finding wide research and manufacturing use in the purification of metals, semiconductors, and organic and inorganic chemicals.

Definition

The general term, zone melting, denotes a family of methods for controlling the distribution of soluble impurities (solutes) in crystalline materials. In all of these methods, a short molten zone travels slowly through a relatively long solid charge and, while traveling, redistributes the solutes in the charge. If the number, size and travel direction of the zones, as well as the initial make-up of the charge, are suitably chosen, many useful operations can be performed on the charge.

A molten zone traversing an ingot has two liquid-solid interfaces – a melting interface and a freezing interface. The zone is able to redistribute impurities mainly because of what happens at the freezing interface.

At the melting interface, solid material is merely melted and mixed with the contents of the zone – thrown into the hopper, so to speak. At the freezing interface, the solute concentration in the just-freezing solid generally differs from that in the liquid. If the solute lowers the melting point of the solvent, its concentration in the freezing solid will be lower than in the liquid. Hence, solute will be rejected by the freezing solid and will accumulate in the liquid. If the solute raises the melting point of the solvent, its concentration in the freezing solid will be greater than in the liquid and the liquid will be depleted of solute. Thus a freezing interface can reject certain solutes, attract others.

The mechanism is closely akin to the basis of separation by fractional crystallization. The main difference is that in zone melting *part* of a charge, rather than all of it, is melted at one time. This change has tremendously increased the efficiency of crystallization as a separation technique and has led to new ways of using crystallization.

The Distribution Coefficient

The results of zone-melting operations can be expressed mathematically in terms of parameters of two kinds: parameters of the apparatus, such as zone length, ingot length, number of passes; and parameters of the material, namely, the distribution coefficient, k, defined as the ratio of the solute concentration in the freezing solid to that in the main body of the liquid.

The value of k will be greater or less than unity, depending on whether the solute raises or lowers, respectively, the melting point of the solvent. The magnitude of k may vary from

Fig. 2 – A Polycrystalline Zone-Refined Ingot of Germanium (Left) Exhibiting Grain Boundaries, Compared to a Highly Perfect and Uniform Single-Crystal Zone-Leveled Ingot

less than 10^{-3} to greater than 10, and will depend on conditions of freezing, such as rate of zone travel and degree of mixing in the liquid. Thorough understanding of the role of the distribution coefficient in freezing is essential to intelligent use of zone melting.

There are several methods for determining the distribution coefficient. If the data are available, the simplest approach is to consult a phase diagram and from it determine the equilibrium distribution coefficient, k_0. From k_0 and from a knowledge of the growth conditions, the effective distribution coefficient, k, can be estimated from an equation.

Few published phase diagrams are accurate at very low solute concentrations – which are of interest where high purity is the object. However, a plot of k_0 versus solute concentration can be extrapolated to zero concentration to obtain k_0 at very low concentration. If only the solidus concentration or the liquidus concentration at a given temperature is known, k_0 can be estimated by a thermodynamic method based on the laws of dilute solutions.

A third approach is to determine k by experiment. It has the merit that the freezing conditions used to determine k can be made the same as those to be used in zone melting. Hence, the growth conditions do not have to be known mathematically; they merely have to be simulated.

As a last resort, for purposes of zone refining, one can determine by trial and error the number of zones that must be passed through an ingot to obtain a desired level of purification.

Zone Refining

Purification is probably the most important object of zone melting. The term zone refining designates zone-melting methods having this object. In zone refining a series of molten zones pass through the charge in one direction. Impurities travel with, or opposite to, the zones, depending on whether they lower or raise the melting point of the charge substance, respectively. They become concentrated in one or the other end of the charge, thereby purifying the remainder.

The degree of separation increases with the number of passes, which is defined as the number of single zones which pass through the charge. The degree of separation approaches a limit as the number of passes becomes infinite. Zone refining can be used to concentrate desired impurities as well as to remove undesired ones. It can also be used in special circumstances as an analytical tool for detecting impurities unobservable by conventional techniques.

Single-Pass Distribution

Consider a cylindrical charge comprised of two components that can form a solid solution. Let its composition be invariant with distance, x, along the ingot. It might be a rapidly frozen casting or mixture of granular constituents. Or it might consist of two rods of the pure components, whose relative cross sections correspond to the mean composition, C_0. Cause a molten zone of length, l, to traverse the charge slowly, as shown in Fig. 3. The zone might be produced by a ring-shaped heater, as suggested in the figure. Assume k to be less than one.

Passing the zone through the ingot distributes the solute approximately as shown in Fig. 4. The curve has three distinct regions – an initial region, a level region and a final region. These arise as follows: When the zone, at full length, is at the beginning of the charge, its concentration is that of the melted material, C_0. As the zone advances a short distance, it freezes out, at $(x = 0)$, a layer of solid concentration (kC_0) of solute, and it takes in, at $(x = l)$, by melting,

a layer of concentration C_0. As a result, the zone is enriched and subsequently freezes out higher concentrations. As the zone progresses, enrichment continues at a decreasing rate until its concentration attains the value (C_0/k). From this point on, the concentrations entering and leaving the zone are equal and the concentration in the freezing solid remains C_0 until the zone reaches the end of the ingot. Thereupon further movement of the heater decreases the length of the zone, causing the solute concentration to rise in the melt.

The initial portion of the curve of Fig. 4 is a region of purification, for the concentration there is less than average. The level portion is a region of uniform composition which is the object of zone-leveling methods (which will be described later).

Multipass Distributions

The merits of zone refining become evident when repeated crystallizations are desired. By using a series of closely spaced heaters, as in Fig. 5, a number of molten zones traverse the charge in a single operation. Separating pure from impure fractions, as in fractional crystallization, is unnecessary. Eliminating this step of handling fractions is probably the chief advantage of zone refining. A second advantage is that time can be saved if the zones are close together, because succeeding crystallizations begin before the first one is complete.

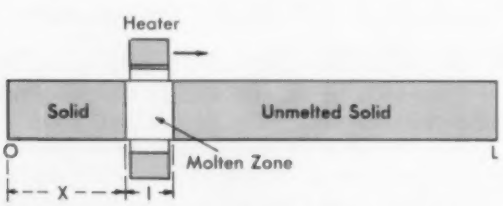


Fig. 3 – Single-Pass Zone Melting. A ring-shaped heater causes a molten zone of length l to traverse a cylindrical ingot of length L.

Other advantages arise from the small size of the molten region. Where contamination of the molten liquid by the container or the atmosphere is a problem, zone refining has the merit, as compared with fractional crystallization, that a smaller proportion of the charge is liquid on the average.

What might be called a physical advantage arises when container-free zone refining is necessary. Certain materials are so reactive when molten that no known container can hold them without contamination. Examples are silicon, titanium, zirconium and, to a lesser extent, iron. Several techniques of zone refining without a container have been developed to handle such materials. These have been possible because only a small part of the charge is molten at any one time.

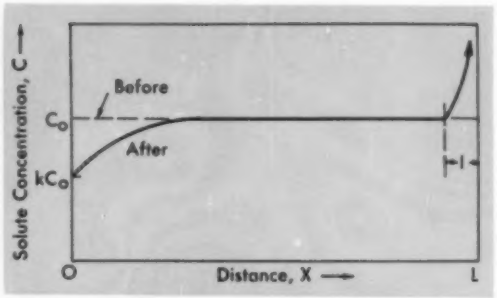


Fig. 4 – Approximate Concentration of Solute After One Molten Zone Passes Through a Charge of Uniform Mean Concentration, C_0

The most widely used is the floating zone technique, in which a molten zone is held in place by its own surface tension between two vertical co-linear rods as illustrated in Fig. 6. This method was first used with silicon, and is being used with other reactive metals.

Large-Scale Application

This question is frequently asked, especially by metallurgists: "Can batch zone refining be used on a large scale economically?" This question can have only a qualified answer because "economical" and "large-scale" have different values for different materials.

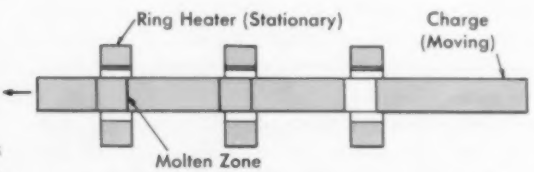


Fig. 5 – Multipass Zone Refining. By using several closely spaced heaters, a number of molten zones traverse the charge in a single operation.

For germanium, a relatively expensive substance, zone refining *is* economical and *is* used on a large scale, but here "large" denotes ingots

weighing about 10 lb., and an annual production of some tens of thousands of pounds. For supplying modest quantities of extremely pure metals that can command a premium price for uses as spectroscopic standards or addition agents for semiconductors, zone refining holds much promise.

The two chief problems to be faced in considering use of zone refining for large-scale purification of a metal are its slowness and the problem of finding a suitable container. The former aggravates the latter. Its slowness (the usual travel rates being of the order of inches per hour) requires that large amounts of material be in process at a given time and that heat to maintain the zones be furnished for a long period. However, by using forced convection, travel rates can be increased to about ten times those customarily used. And, although a container is no doubt desirable, a technique has been devised which permits large-scale operation without one.

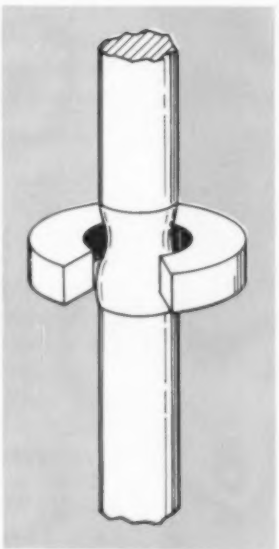


Fig. 6 – Zone Refining Without a Container. The most widely used is the floating zone technique in which a molten zone is held in place by its own surface tension between two vertical co-linear rods

Continuous zone refining eliminates much of the difficulty of handling small batches of material. More important, it enables practical operation close to the ultimate distribution.

In continuous zone refining, impure feed continuously enters at the midpoint of a column through which molten zones are traveling, while pure product leaves at one end and impure waste leaves at the other end. This gives a large yield of purified material per unit of time.

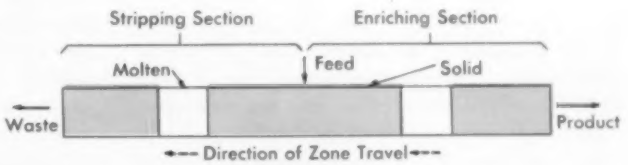


Fig. 7 – Continuous Zone Refining. Impure feed continuously enters at the midpoint of a column through which molten zones are traveling. Pure product leaves at one end and impure waste leaves at the other end. The method gives a large yield of purified product per unit of time

The essential features of a continuous zone-refining process are represented in generalized form in Fig. 7. Molten zones, produced by moving heaters, travel slowly down the charge or column (to the left in figure). If there were no flows of feed, waste, or product, the process would simply be batch zone refining, the action of the zones being to sweep solute *down* the column, solvent *up* the column. For the process to be continuous, with stripping and enriching sections in the column, feed must enter, divide into two flows through the two column sections, and leave as waste and product as indicated.

A continuous zone-refining process must accomplish both objectives – the indicated movements of zones and the indicated flows of material. To be successful, the process must accomplish these objectives simply. Several different methods of doing this have been devised.

Zone Leveling

The objective of zone leveling is to produce a uniform, or level, distribution of solute in an ingot – in other words, to prevent segregation. It is virtually impossible to obtain a uniform concentration of a soluble impurity from one end to the other of a crystal grown slowly from the melt by the conventional means. Because the freezing crystal differs in composition from its melt by a more or less constant factor, the composition of the melt changes as freezing progresses. The resulting ingot segregation can be very severe.

By using one of several zone melting techniques known as zone leveling, segregation can be almost completely eliminated. While possibly less well-known and less generally applicable than zone refining, the zone-leveling techniques have solved an irritating problem of long stand-

Fig. 8 – Silicon Rod Being Treated by the Floating Zone Technique. (Courtesy H. C. Theuerer)

ing in the field of solidification, and they have already gone into commercial use.

Single crystal growing is not a necessary concomitant of zone leveling or zone refining. However, the two are often performed together because crystalline perfection and control of soluble impurities are often required together in substances such as semiconductors. Extremely perfect crystals of semiconductors have been grown by these methods.

Preparing Junctions

New applications for zone-melting techniques are constantly being devised. The object of zone remelting is to produce p-n or n-p-n junctions. In this process, a single crystal of germanium is prepared containing uniform concentrations of two carefully chosen solutes – one producing n-type and the other p-type conductivity.

When both are present, the observed conductivity-type corresponds to the solute whose concentration is greater. A portion of a block cut from such a crystal is next melted and slowly refrozen. By this simple operation, the solutes are redistributed in such a way that p-n or n-p-n junctions result.

Temperature Gradient Method

In another technique, known as temperature gradient zone melting, moving heat sources are unnecessary, as the molten zones are moved by means of a stationary temperature gradient. A feature of this technique is that molten zones of extremely small dimensions can be caused to move about in a solid crystal.

For example, a sheet of aluminum 0.003 in. thick can be made to migrate in molten form through a ¼-in. slab of silicon by applying a temperature gradient at right angles to the sheet.

Here's an explanation of why the molten layer moves: When the aluminum sheet is heated, it forms a low-melting-point alloy with silicon by dissolving silicon from the block. Because of the impressed temperature gradient, one interface of this thin layer is hotter than the other. This means more silicon dissolves there. This also sets up a concentration gradient of silicon across the layer, causing silicon to diffuse from the hot interface to the cooler interface, where it freezes.

The continued solution of silicon at the hot interface and freezing at the cooler interface results in movement of the molten layer through the hotter block. This technique provides a method for fabricating new types of semiconductor devices. It has many other uses as well which are now being explored.

Future Pattern

Experts make these predictions on the course zone refining will take in the next few years: It will become established as a valuable laboratory tool for preparing pure metals and other materials for research purposes. A number of small-scale commercial applications to metals will develop. Sooner or later, a large-scale process will be proved feasible. Commercial use in the field of semiconductors will steadily increase.

Many applications in the chemical field will materialize, including continuous processes. Sometimes the best way to a pure metal is through its salt. A case in point is gallium. It responds but slowly to zone refining when the metallic form is treated but refines very well in the form of gallium chloride ($GaCl_3$), which can be converted to metal after zone refining.

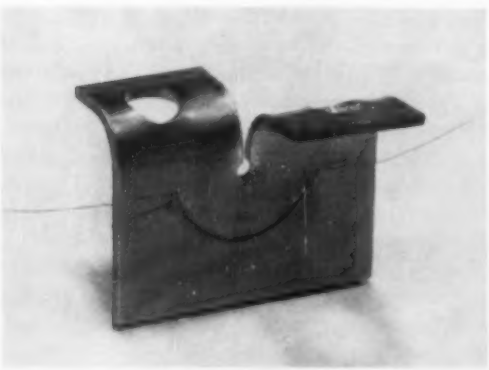
Tear Test for Titanium Sheet

By C. W. VIGOR
*and J. R. HORNADAY, Jr.**

Small coupons are torn by a conventional tensile testing machine. The amount and duration of applied force are recorded and used to determine the work required for tearing. Resulting data measure effect of hydrogen embrittlement, and thermal instability.
(Q26q, Q26s, 1-54; Ti, *H*)

TITANIUM SHEET containing hydrogen in excess of 200 to 400 ppm. frequently tears or cracks when formed. Further, even if the sheet is successfully fabricated, parts may subsequently crack in storage or in service. As a result, titanium sheet is now required to contain less than 100 ppm. hydrogen. Since hydrogen embrittlement is not always evident in conventional bend and tensile tests, fabricators have found supplemental tests to be quite helpful. One such test is a tear test developed by Dr. Leo Schapiro; it successfully predicts the formability of titanium sheet.

Fig. 1 – Tear Test Specimen With Copper Marker Wire Prepared for Testing



At our laboratory this test was adapted for a comprehensive study of embrittlement phenomena in titanium. Since the problem now was to detect much lesser degrees of embrittlement than usually measured, we had to alter the test procedure and interpret the results in a different manner. Our subsequent research proved the revised test to be quite successful.

Test Procedure

Specimens are prepared by shearing sheet into 1-in. squares and drilling a 1/16-in. hole in the center. A saw cut is made to this hole, two ¼ in. holes drilled and the ears bent in a simple fixture. A test piece ready for tearing is shown by Fig. 1. Hooks are engaged in the holes of

*GM Research Staff, General Motors Corp., Detroit.

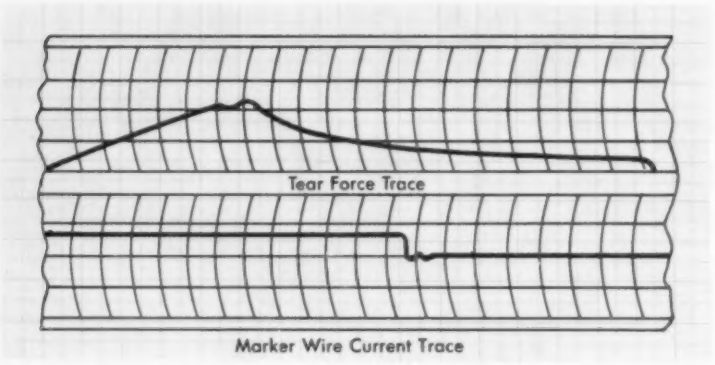


Fig. 2 – Typical Oscillograph Trace of Tear Test

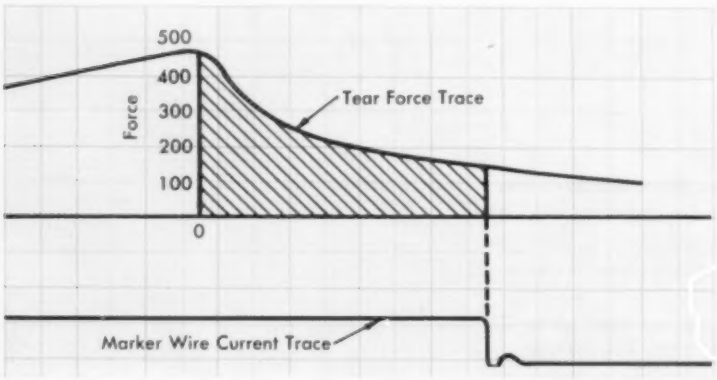


Fig. 3 – Oscillograph Trace Replotted in Rectilinear Coordinates to Measure Tear Work. The shaded area represents work done to tear the first ¼ in.; a planimeter is used to measure this area

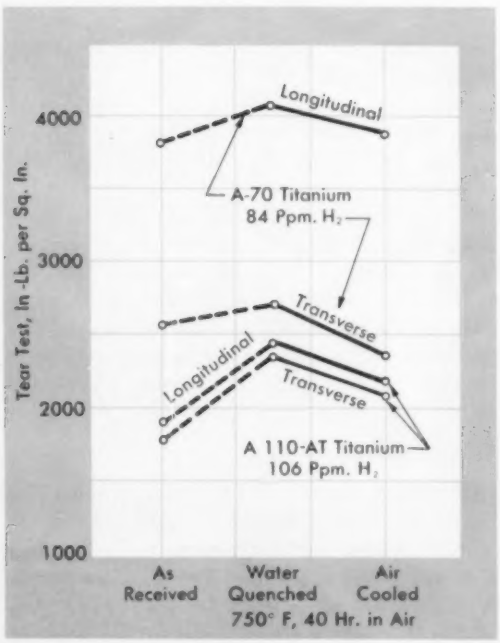
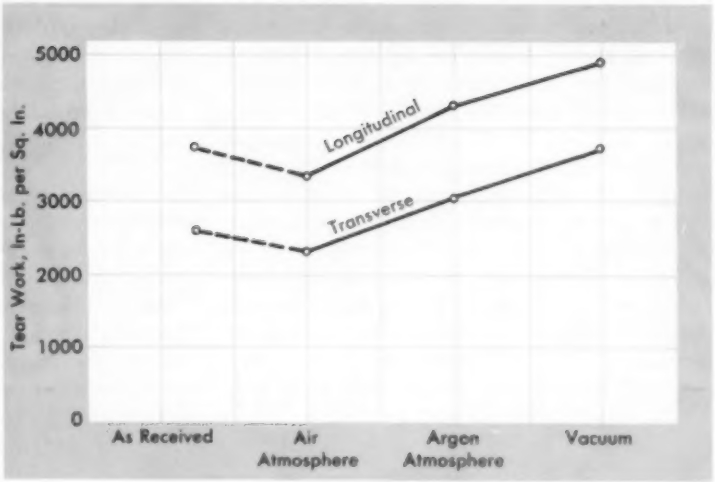


Fig. 4 – Effect of Hydrogen Precipitation on Tear Test Results

the bent ear and the sample is pulled apart in a conventional tensile machine. A lightly scribed arc of ¼ in. radius serves as a reference point for checking the load as tear progresses; tear duration is aproximately 3 sec. A high-speed oscillograph and a resistance strain gage load cell autographically record the load while the test progresses.

Preliminary work showed that the most significant differences between ductile and slightly embrittled samples occurred during the first ¼ in. of tear. In addition to variations in the tear load, the rate of progression of the tear appeared to be more rapid for the more brittle samples. Therefore, it was considered necessary to determine accurately the time interval for the first ¼ in. of the tear. To do this, a 0.0025-in. diameter enameled copper wire is placed along the scribed ¼-in. arc and secured with an epoxy resin. When the sample tears, the wire breaks and disrupts a 6-v. circuit; this event is recorded on another channel of the oscillograph. A typical oscillograph trace for tear load versus time is shown in Fig. 2, along with the trace depicting the disruption of the marker wire current.

Fig. 5 – Effect of Atmosphere on Tear Properties of Commercially Pure Titanium. Specimens were heated at 750° F. for 40 hr. and cooled slowly



Interpretation of Test Results

The work input during the first ¼ in. of tear is measured by integrating the area under the tear force trace. To measure this area with a planimeter, the curve is replotted in rectilinear coordinates, as illustrated in Fig. 3. The area is proportional to the work required to tear the sample and is expressed in inch-pounds. Since satisfactory correlation between samples of varying thickness is obtained by dividing the work function by the cross-sectional area of the torn interface, the graph units are in-lb. per sq.in.

Since some scatter is obtained, statistical treatment of the data is necessary to establish the average of the tests made for each condition.

Fig. 6 – Effect of Exposure Time at 900° F. in Air on Tear Resistance of A110-AT Alloy and A 70

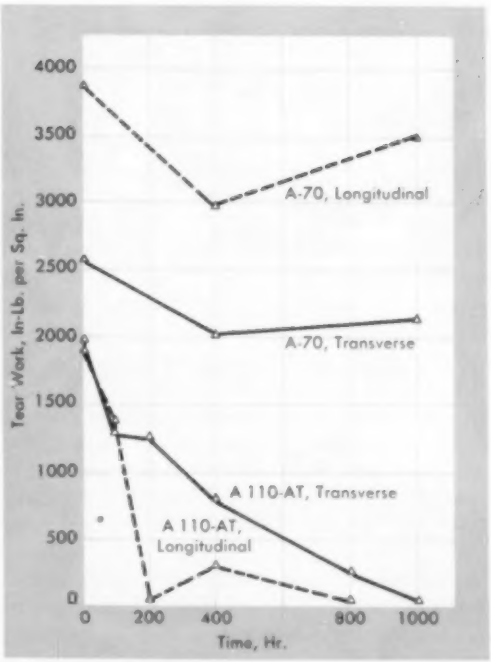
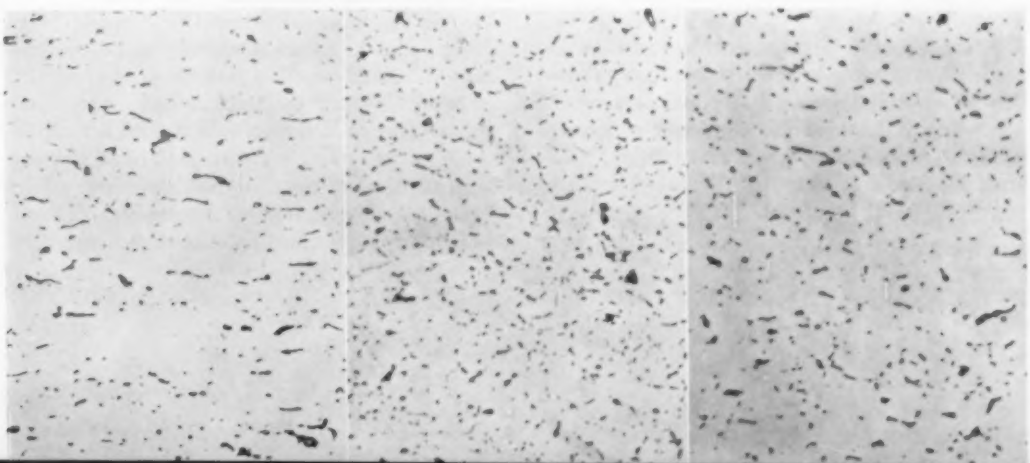


Fig. 7 – Photomicrographs of Etched 5% Al, 2.5% Sn Titanium Alloy. Left is as-received; center is embrittled by heating in air 1000 hr. at 900° F., right has ductility restored by annealing 30 min. at 1500° F. All 500×



Hydrogen Embrittlement

As an example of the manner in which the effect of hydrogen embrittlement has been investigated, commercially pure titanium (A 70) and a 5% Al, 2.5% Sn alloy (A 110-AT) were heated in air at 750° F. for 40 hr. Specimens were then either water quenched to retain the hydrogen in solid solution, or air cooled to precipitate a hydride phase. Figure 4 summarizes the results obtained from tear testing; the quenched samples were more tear resistant than the air-cooled samples. Also revealed are the marked directional properties which exist in the commercially pure material.

As Fig. 5 reveals, the atmosphere surrounding the test affects the tear strength. Since the tear resistance increases in an argon atmosphere or a moderate vacuum, it appears that vacuum treatment removes hydrogen, treatment in argon retains hydrogen, and treatment in air results in some additional hydrogen.

Thermal Instability

The tear test has also been used to investigate embrittlement due to thermal instability. A severe degree of tear embrittlement has been found to occur in the 5% Al, 2.5% Sn alloy after heating in the range of 750 to 900° F., for periods between 200 and 1000 hr. A 110-AT samples exposed at 900° F. exhibited decreasing tear resistance as a function of exposure time (Fig. 6).

Book Review...

A Manganese Steel Data Book

Reviewed by *D. N. ROSENBLATT**

MANGANESE STEEL, published for Hadfields Ltd. of Sheffield by Oliver and Boyd, Edinburgh, 1956. 128 p., 44 illus. 18s.

THIS VOLUME purports to enlighten the engineer, metallurgist, and student by presenting the full story of the invention, development and use of austenitic manganese steel. The staff at Hadfields Ltd. have turned out a commendably thorough job.

"Manganese Steel" represents one of the most exhaustive expositions on a single material that this reviewer has seen. The practical man will appreciate it because the emphasis is directed towards application rather than theory. The book clearly delineates the service conditions which dictate and govern the sensible commercial usage of austenitic manganese steel. Examples of both favorable and unfavorable service conditions are represented.

This book should help to clear up a myriad of misconceptions about manganese steel which exist due to the lack of understanding of the physics of work hardening in austenitic materials. The chapter on "Transformational Characteristics and Metallography" should be gratefully received by those who have had to defend that point of view which insists that the work hardening phenomenon in maganese steel does not involve the classical martensitic type of hardening commonly associated with phase transformation. In this section the authors have stated categorically that "the increase in hardness from about 200 to a maximum in the region of 550 Brinell, which results from cold working, has been attributed by many investigators to the transition of austenite to martensite. In our many and varied investigations of this property,

*Assistant Manager and Chief Metallurgist, American Foundry & Machine Co., Salt Lake City, Utah.

Results for the A 70 titanium are included for comparison. Increase in anisotropic behavior of A 110-AT alloy after the first 100 hr. of exposure is very apparent. Hydrogen pickup was not responsible; samples enclosed in argon-filled pyrex bulbs and heated under the same conditions were also brittle. Consequently, further work was necessary.

Examination of the microstructure did not reveal structural differences between embrittled and ductile material when the samples were etched to develop the general structure. However, very light etching revealed a previously unobserved phase existing in the as-received material in the form of coarse platelets aligned somewhat parallel to the rolling direction. Embrittled samples also contained this phase but in a finer dispersion and with a pronounced tendency to outline grain boundaries. Annealing at 1500° F. eliminated the grain-boundary precipitation and restored the ductile tear characteristics. The three microstructures are illustrated in Fig. 7.

Summary

We feel that the tear test is a valuable supplement to existing methods for evaluating titanium sheet quality, although, like impact testing, it does not yield specific engineering information. Furthermore, in addition to its control potentialities, it offers a new approach to the study of embrittlement.

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using all the possible methods of identification available, no evidence of the presence of martensite resulting from cold deformation has ever been found, and the absence of magnetism in the deformed material is a powerful argument against the postulated transition."

While the succeeding sections of the book are particularly directed to the physical metallurgist, there is sufficient meat to sustain the interest of other readers inclined toward patient curiosity in spite of an occasional tendency to resort to specialized verbiage.

It is interesting to note, occasionally, the subtle deviation of British terminology from the seemingly more functional American metallurgical jargon. In seeing such terms as "decarbonization" one is reminded of ancient chemical texts which refer to "sodium nitrate" as "niter of soda". The analogy is, however, limited. One cannot justifiably infer that this selection of language has in any sense discounted the adroit, thoroughly sound metallurgical data.

The chapter on work hardening, abrasion and wear resistance attests to the thorough and impartial manner in which the book explores the entire scope of behavior and application of manganese steel. The merits and limitations of austenitic manganese steel, determined not only by laboratory wear tests but also by actual service testing, are given. Its limitations when employed to resist abrasion have been adequately noted: "It may be generalized that where manganese steel has proven unsatisfactory, the poor life is due to the working conditions being such that adequate work hardening is not produced. In certain forms of beaters for lime crushing, manganese steel gave only a very short life. The conditions were not onerous and did not promote development of work hardening." On the other hand, the service situations in which manganese steel produces its most dramatic superiority are particularly noteworthy: "In London Underground Network, hundreds of crossings in manganese steel are giving years of trouble-free service, where carbon steel rails formerly only afforded months." There are many examples including one describing tumblers working in a dredger engaged in dredging gravel. "The average rate of wear over the life of the tumblers is approximately 13 times as great for carbon steel as for manganese steel."

The final three chapters of the book which relate to electrical applications, machining, and joining, are educational and informative to scientists and practicing metal workers who both require reliable reference data.

In the concluding section is an excellent collection of photomicrographs showing a variety of physical and thermal histories.

The book includes an extensive bibliography.

While it is generally accepted that a technical book should present cold facts, the austerity surrounding the facts in this volume occasionally borders on tedium. This reviewer felt the book at times suffers from the studied avoidance of mentioning unproven theory. Although the book sticks to proven facts, it does not serve to inspire creative research. However, it abounds with well-organized data and should be useful in any metallurgical library.

Cermets in Jet Engines

*By J. W. GRAHAM and W. F. ZIMMERMAN**

Despite the extensive experimental work in the last ten years, cermets, because of their inherent low impact strength, have not proved suitable for jet engine components. Since substitutes with the needed properties have become available, research work on cermets is now confined to basic principles. (T7h, 17-57; SGA-h, 6-70)

As MENTIONED in the previous article, cermets were originally conceived by the Germans as a logical material for jet engine parts. The idea, of course, was to produce a material with the temperature resistance of ceramics and the strength and ductility of metals. This concept appeared reasonable to American engineers and they began their own research into cermet properties when the war was over. Work continues today, but, while cermets have proved suitable for other purposes, their major drawbacks for jet engine parts — low impact strength and low ductility — have not been overcome.

Despite these detrimental properties, it seemed likely, earlier, that cermets could be adapted for turbine buckets operating up to 1800° F. Many ingenious design and test innovations were devised to minimize their inherent lack of ductility. Single-and-well-filleted dovetails, ductile shims, photoelastic methods of evaluating dovetail designs, static and dynamic testing, skewed and curved bucket roots, and other improvements all helped to lessen turbine bucket dovetail failures. An exploded view of a bucket, illustrating some of the mechanical improvements, is shown in Fig. 1.

Testing

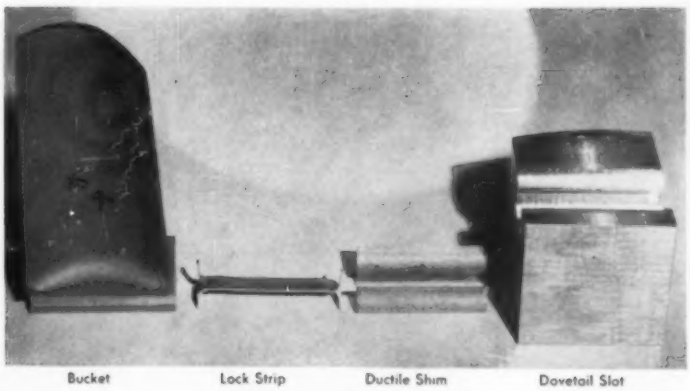
Along with these developments, intensive efforts were devoted to quality control in both manufacturing and inspection operations. Here is an example. Certain buckets failed in a short time while others operated for extensive periods. To eliminate inferior buckets, manufacturing processes were more rigidly controlled and the entire history of each bucket was recorded from the lot number of the starting materials through the pressing, sintering, dovetail grinding, inspection, static proof loading, moment weight measurement, and determination of resonant vibration frequencies. Furthermore, inspection techniques included radiography, hardness testing, density measurement, fluorescent dye penetrant testing, and, ultimately, ultrasonic examination. And still the bucket life could not be predicted.

One of the major problems was "secondary impact damage".† To reduce this effect, engine tests were generally run with two to six cermet parts in the entire assembly. In addition, sheet metal shroud rings surrounding the turbine wheel were installed in some engines; particles from broken cermet buckets could then penetrate the shroud without shattering other buckets. Successful engine tests of 150 hr. have been made with partially cermeted turbine and nozzle partition assemblies. However, there was reluctance to run fully cermeted assemblies until the reliability of these parts could be increased. One effort in this direction was to eliminate minute, undetectable surface flaws by nickel-plating the part; a subsequent diffusion heat treatment was expected a heal any minor imperfections. However, this method was not very successful. Even if it had been, the lack of

*Aircraft Gas Turbine Div., General Electric Co., Evandale, Ohio. This is the second of two articles on cermets, the first appearing in *Metal Progress* for March 1958.

†"Secondary impact damage" refers to the damage suffered by intact buckets (in the same turbine, of course) when they are struck by pieces of broken buckets.

Fig. 1 – Exploded View of Bucket Assembly Showing Bucket, Lock Strip, Ductile Shim and Dovetail Slot.



impact resistance in cermets still loomed as a serious obstacle.

The effect of component shape on the impact resistance of nozzle vanes and turbine buckets was evaluated by "ballistics impact tests"*. Trailing edge thicknesses needed to prevent impact failure in airfoil components made from cermets then available were determined and found to be greater than aerodynamically permissible.

Clad Cermets

Materials engineers of several laboratories began, about three years ago, to develop and evaluate ductile metallic surface coatings on cermets. Here the ballistics impact test was also useful, as Fig. 2 illustrates. The General Electric Co., using sheet metal cladding techniques, applied single and composite sheet metal layers to cermet bucket airfoils, and conducted an extensive testing program upon them. During these tests, minor breakages did occur, as Fig. 3 shows. The major failures which also occurred were associated with stresses in the cermet which were concentrated at the lower edge of the cladding; these stresses were due to both the differential thermal expansion and contraction between the two materials, and the cermet's lack of ductility. Stress cracks appeared before total failure; a typical example is illustrated by Fig. 4.

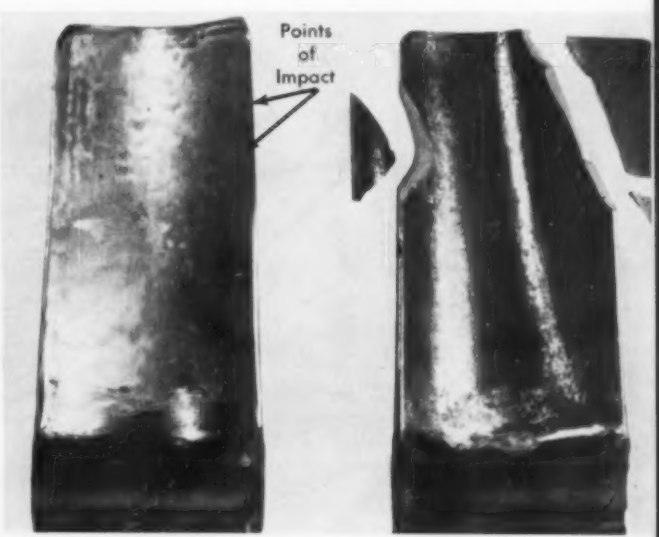
Infiltrated Cerments

While cermet research work has been mainly concerned with the improvement in impact strength, the infiltration technique for TiC was the only significant development. This innovation, described in *Metal Progress*, December 1956, p. 101, consists of sintering fine TiC powder to form a porous skeleton of the desired shape and infiltrating it with a metallic binder so that ductile metal surrounds the TiC particles. Unfortunately, the impact resistance was still inadequate; though much stronger, the infiltrated TiC cermet buckets were incapable of absorbing secondary impact damage.

In view of the engine test failures on sintered cermets, clad cermets, and infiltrated cermets, it appeared that further testing of cermets as turbine buckets was unwarranted until some new and unique material could be devised, or some design or testing improvements could be made.

*The impressive title refers to a simple method: A pellet is fired at the target (in this case, the cermet part) by an air rifle. It is possible to reproduce, to some extent the nature, weight, velocity and direction of expected impacting particles which might be expected.

Fig. 2 – Clad Buckets (Left) and Unclad (Right) Tested by Ballistic Impact



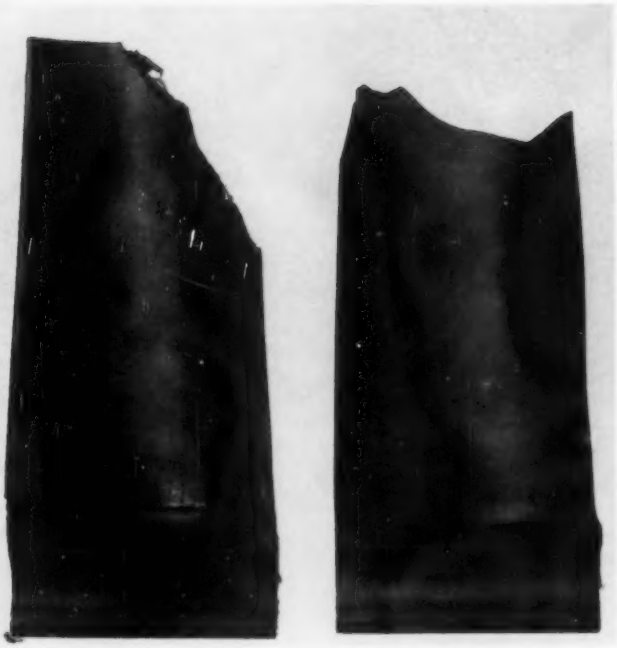


Fig. 3 – Tip Failures in Airfoils During Engine Test

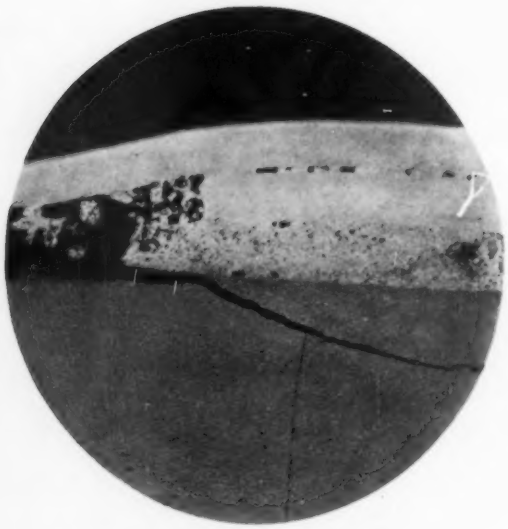
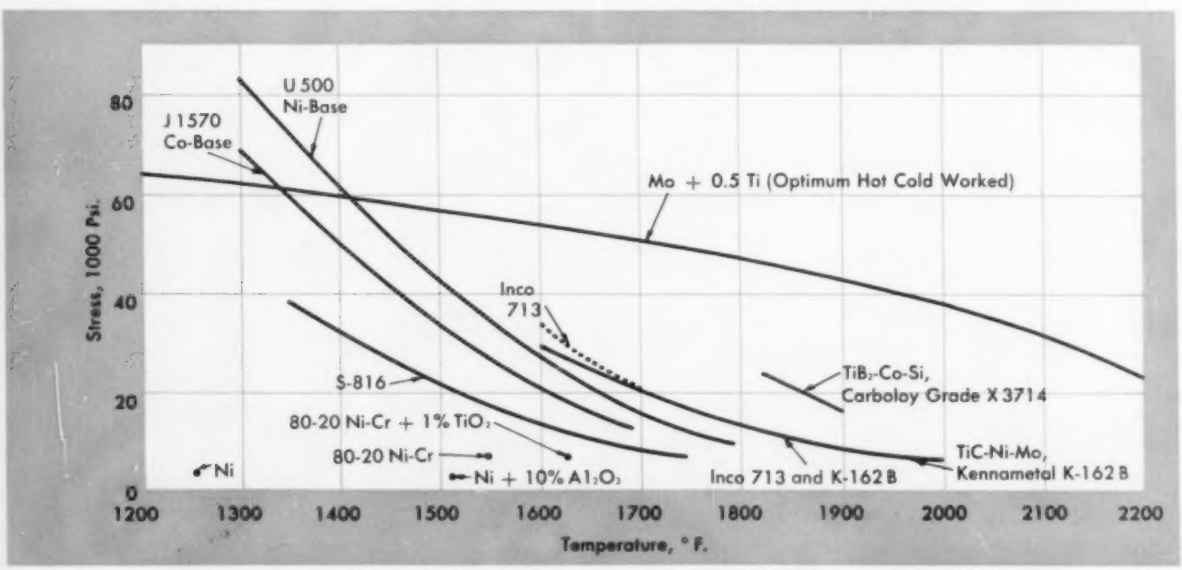


Fig. 4 – Stress Crack at Junction of Cladding and K-162B Cermet. Bucket failed during engine test

The Competition Against Cermets

As everyone knows, jet planes soar overhead daily. Since it is evident that they don't have cermet buckets, the question arises: What do they have? Well, during the decade in which the potential of cermet materials for hot gas components of aircraft was being so earnestly pursued, continued improvements were being made in competing materials. There are three types – *(a)* superalloys, usable from 1650 to 1800° F.; *(b)* coated and clad molybdenum; *(c)* nickel, iron, molybdenum and other metals strengthened by dispersion hardening. Only the first of these is in actual use in production of turbine buckets.

Fig. 5 – 100-Hr. Stress-Rupture Strength of Typical Superalloys Compared With Some Cermets. Two dispersion hardening alloys are also included



Effect of Dispersion Hardening

Composition	Temp.	Stress	Life
Mo	1800	25,000 psi.	80 hr.
Mo+1% ZrO_2	1800	25,000	170
Ni	1500	5,000	0.2
Ni+10% Al_2O_3	1500	5,000	145
80-20 Ni-Cr	1600	10,000	15
80-20 Ni-Cr+1% TiO_2	1600	10,000	188+

The advantage of a 1500 to 1800° F. increase in turbojet engine operation originally promised by cermets has, in part, been eliminated by the further improvement of conventional alloys. Such alloys as J-1570, U-500 and Inco "713" have temperature resistant properties comparable to those of the cermets along with much greater impact strength.

The stress-rupture life of 80-20 Ni-Cr al'oy and of molybdenum can be improved by the addition of insoluble oxide particles; this technique is called "dispersion hardening". Results are listed in the table above.

These data, when converted and plotted as in Fig. 5, indicate that the 100-hr. stress-rupture curve for nickel would be raised by 250° F. while that of 80-20 Ni-Cr would be 75° F. higher. Since work on dispersion hardening by insoluble particles offers considerable promise, this field is being intensively investigated, and, unlike cermets, alloys highly resistant to impact should be readily produced. Figure 5 compares the 100-hr. stress-rupture properties of typical cermets with some superalloys and two dispersion hardening alloys.

Summary

At the beginning of the cermet era, the intense need for high-temperature turbine components forced the design engineer to attempt, hopefully, to use cermets for turbine buckets. This hope proved to be a vain one because of the inherent low impact strength. Though cermets have been successful in other areas where their excellent stress-rupture properties were needed, the constant attempt to apply them in turbojet engines, and their ultimate failure, emphasizes some of the difficulties in advancing the high-temperature materials frontier.

Prospects of improving cermets do not appear good at this moment. Other materials have either surpassed them as high-temperature, highly stressed hot gas components or have opened more promising avenues of approach. Consequently the effort to improve cermets has reverted to studies of a more basic nature.

Short Runs...

Electrochemical Marking of Metal

*By RALPH A. BOTOSAN**

THE NUMBERLESS APPLIANCES, motors, machines, and other manufactured items produced today require an endless variety of interchangeable metal parts, and some method for identifying them is generally essential. To be of any value, the identification should be permanent and yet not disturb the surface. As an example, a fine surface finish would be spoiled by stamping. Other materials – toolsteels, for instance – are too hard for a surface impression.

Parts such as these can be marked by electrochemical methods; the identification is etched

*Director of Research, Electromark Corp., Cleveland.

Part Being Marked Electrochemically

or plated on the metal surface and becomes part of the metal. Three types of marks are possible. In each an absorbent pad is fastened to the electrode and covered with a nonconducting stencil. A power unit is also required. To produce a plated mark, a d-c. source is used, the negative contact being connected from the power source to the material. A plating solution is placed on the felt pad and the electrode is connected to the positive pole of the power unit. When the electrode is placed on the part, a plated mark appears in the form of the stencil.

To etch a mark, the leads from the d-c. power source are reversed and the positive contact is connected to the work. The etch can be produced in about 1 sec. If an a-c. power source is used, a stable oxide of a contrasting color produces the mark. This type of mark is generally used for ferrous metals. A typical electrolyte for marking steel is sodium chloride.

By proper selection of electrolyte and power supply, a variety of marks can be produced on many metals; steel, aluminum, titanium, uranium and zirconium are typical examples.

Boron in Cast Steels

BORON is now being used to increase the hardenability of cast steels. The first application of boron in this manner was for the production of cast steel armor during the Korean conflict. This armor, which was used for tanks and tank transmission cases, could be hardened to a considerable depth. Subsequently, foundries began to use boron in medium-alloy steels which were to be used for high-wearing heavy-section parts. The sprockets of the heavier Caterpillar tractors, though they are of a carbon steel rather than an alloy steel, are a typical example.

Early in 1955 metallurgists at Caterpillar Tractor Co. began to concern themselves with the possibility of increasing the hardness depth of sprocket wearing surfaces. After much discussion, it was decided that the experimental heats should be made in the acid openhearth furnace since it provides good control of the melting process and high productive capacity.

On Dec. 11, 1955, the first experimental heat was made. A total of seven heats of 25 tons each sufficed to establish the melting practices. Preliminary test results were very encouraging. Samples of the first boron steel heat hardened 2½ times as deep as carbon steel.

On the basis of final test results, the sprocket was redesigned to provide enough metal section to utilize effectively the depth of hardness developed by heat treatment. Regular production began in October 1956. The photograph illustrates a typical sprocket section.

Hardness Depth Produced by Heat Treatment of Cast Boron Steel Sprocket

Is heat treating costing you more than it should?

A FRANK APPRAISAL OF YOUR METHODS MAY WELL BE IN ORDER!

Every so often, it pays to re-evaluate every production phase in the light of new developments. This is especially true of heat treating. A method change here or a piece of more modern equipment there can spell vitally important cost savings . . . a fact that Ajax has proved in hundreds of cases.

The outstanding basic advantages of salt bath heat treating for most applications are now, of course, well known. These include: faster, more uniform heating by conduction; elimination of atmosphere problems; negligible distortion; ease of selective heating; faster production in less space with unskilled labor; and various others.

Not so well known, however, are important recent developments in salt bath furnace types. The new Ajax design in which a pair of submerged electrodes can be changed in a short time without tearing down the pot is an example. Ajax Cataract Quench Furnaces which give molten salt quenching power equal to that of oil are another. Ajax gas-fired salt baths are still another.

Equally important, there have been 10 league strides in applying salt bath processing to still better advantage and in mechanizing it for substantial labor cost reductions.

As salt bath pioneers and with connections in many parts of the world, it is only natural that Ajax should have led in most of these while being thoroughly familiar with all.

The chief product of Ajax is heat treating "know how" . . . not merely the largest assortment of salt bath furnace types on the market.

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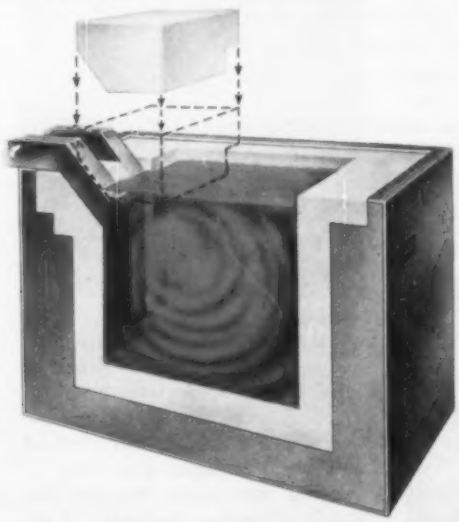

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Etch Pits of 30 Years Ago

LONDON, ENGLAND

Reading the interesting article on etching methods of observing dislocation sites in iron by F. W. C. Boswell in your December issue (p. 92), I remembered some similar photographs which I took in 1928.

In Fig. 1 can be seen strings of etching pits, one of which has curled itself around an inclusion. The material is Armco iron etched with 0.5% nitric acid in alcohol for half an hour. The magnification is 1500 ×.

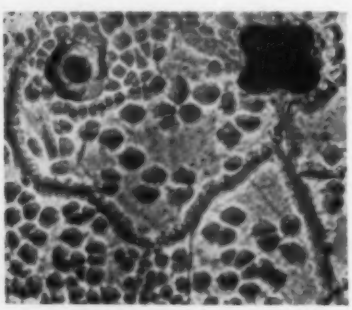


Fig. 1 – Etch Pits in Armco Iron. 1500×

A more interesting example of this type of phenomenon is shown in Fig. 2 and 3. These illustrate the diffusion of tin into Armco iron. Figure 2 is a cross section of the diffusion band showing the formation of columnar crystals, with a veined substructure within the columns. The tin is diffusing from the top and the advancing front of the tin can be seen by the horizontal band about two-thirds of the way down from the top of the photograph. Figure 3 is a higher magnification of this diffusion band at 600 × with the iron in the top right-hand corner and the diffusing tin-iron alloy in the bottom left-hand

Fig. 2 –Diffusion of Tin (Top) Into Armco Iron

corner. A close examination of the diffusing front shows that it is broken up with a network of fine etching pits (not clearly resolved at this magnification). Here we probably have an illustration of a dislocation array caused by invading foreign atoms on the lattice. It would be most interesting to re-examine the geometry of such diffusion fronts using the more refined techniques of Mr. Boswell.

These photographs were published in two papers by C. O. Bannister and W. D. Jones in *Journal*, Iron and Steel Institute, Vol. 123, 1931, p. 395, and Vol. 124, 1931, p. 71.

W. D. JONES
Consulting Metallurgist

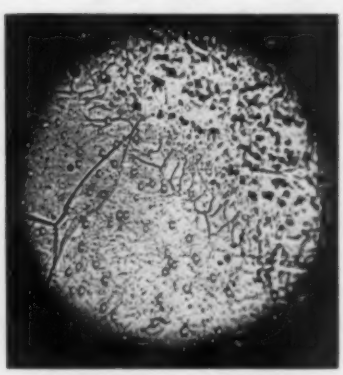


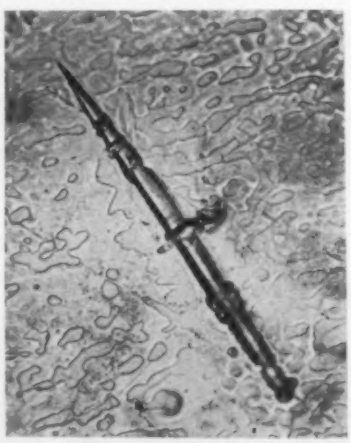
Fig. 3 – Same Diffusion Band as Fig. 2 at 600×. Diffusing tin-iron alloy at lower left

Missiles in Meteorites

SAINT-MANDE
SEINE, FRANCE

Under the title "Meteorites for Missiles", I read in the September issue of *Battelle Technical Review*:

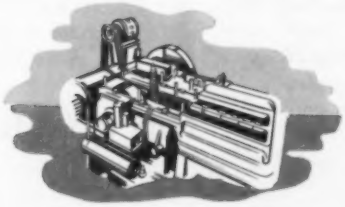
"Nature's own space missiles hold secrets that can aid in the development of modern-day missiles. For this reason, meteorites, which are nature's primitive missiles, are currently under examination by technologists."



I dedicate to the Battelle scientists and to those in charge of "Vanguard Project" the accompanying micrograph. This picture at a magnification of 275 diameters, was obtained after electropolishing a specimen of meteoric iron in the Museum National d'Histoire Naturelle, Paris (National Museum for Natural Science).

PIERRE A. JACQUET
Contracting Engineer for Naval Structures and Weapons, French Navy

(*Correspondence cont. on p.* 116)

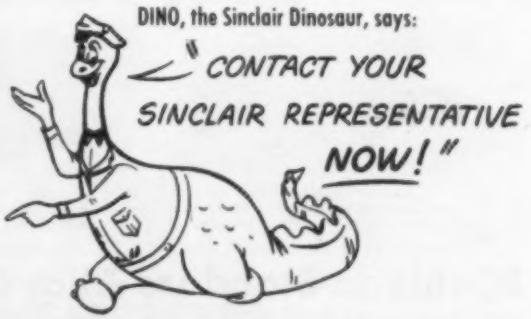


"For three weeks their production was zero"...

A midwest plant was faced with a serious production problem in aluminum extrusion. The operation, on a ⅜" cold upset extruder, was to form a clinching cap for a metal screw. In three weeks of experimentation they did not produce one acceptable product, although they had tried a variety of piercing tool lubricants, including both oil and wax.

The plant foreman called in J. V. Ritz, a Sinclair Area Engineer. Mr. Ritz reports: "After studying their lubrication problem, I decided that Sinclair TRUKUT,® used in the neat form, would provide the correct lubrication. Three hours after they followed this advice, their machine was producing perfect caps at full capacity. *In fact, they produced more caps in a twenty-minute run than had been produced in the previous three weeks.*"

If you have a lubrication problem in your machining operation, call on the experience of a Sinclair Lubrication Engineer. Contact your local Sinclair Representative, or write to Sinclair Refining Company, Technical Service Division, 600 Fifth Avenue, New York 20, N. Y. *There's no obligation.*



SINCLAIR

CUTTING OILS and COOLANTS

Ambiguous Type Number

PHILADELPHIA

The article by Joseph R. Lane in December 1957 *Metal Progress* proposes the assigning of Type No. 349 to the low-cobalt version of Type 347 stainless steel. Before your readers adopt this usage and perpetuate the confusion it creates, attention should be called to the fact that No. 349 has for many years been the unofficial designation for 19-9 W-Mo arc welding electrodes.

Several electrode manufacturers, certain user specifications, and the MIL-E-16715 Government specification (January 1954) call the 19-9 W-Mo composition "Type 349". The N.E.M.A. standard for identification of covered arc welding electrodes has called it Type 349 since 1953.

Since the proposed low-cobalt alloy will be needed only for nuclear applications, there should be no hardship in assigning a more distant number to it, in order to avoid conflict with existing Type 349 designations for welding electrodes.

HALLOCK C. CAMPBELL
Director of Research
Arcos Corp.

Note to Graduates

BERLIN, WEST GERMANY

During the last war terrible damage was done to the Technical University in Berlin. The buildings are being replaced and the University is resuming its former position as an important educational institution for inquiring minds.

One thing must be reconstituted bit by bit, and that is the alumni records. This note is therefore an urgent request to any graduate of the Technische Hochschule whose eyes may see it to forward a little information to the undersigned — namely, the year of his entrance, the year of graduation, his present address and his present occupation.

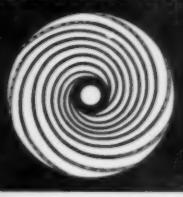
PROF. DR-ING. P. RIEBENSAHM
Berlin-Charlottenburg
Hardenbergstrasse 23

Letter From Canada

VALCARTIER, QUEBEC

METAL PROGRESS has published considerable information about the metallurgical activities within our Department of Mines and Technical Surveys, but nothing of similar work done since 1947 by the Defence Research Board of Canada. Activities in three of its own establishments might be mentioned first: the Pacific Naval Laboratory (PNL) in Esquimalt, the Naval Research Establishment (NRE) in Halifax and the Canadian Armament Research and Development Establishment (CARDE) in Quebec. In addition to this, extramural research is carried out in other government research departments, independent laboratories, such as the National Research Council and Atomic Energy of Canada, and in appropriate graduate schools in our universities. Research projects are carefully chosen on the following basis: The work has to be applicable to environmental conditions prevailing in Canada, be required by armed forces, and not be available from friendly countries. It should also

MICHIGAN-STANDARD ALLOY CASTING CO.
Announces
NEW CENTRIFUGAL TUBE PRODUCTION EQUIPMENT



Michigan-Standard Alloy Casting Co. now has the latest in Centrifugal Tube production equipment

We can offer a variety of cast tubes ranging in sizes from 3" minimum inside diameter to 12" maximum outside diameter, up to 10 foot lengths and in all heat and corrosion resistant alloys.

Misco Sales Engineers and Metallurgists stand ready to help you make economic use of the advantages given below on centrifugally cast tubes:

Surface on the outer diameter of the tube smoother yet rough enough not to decrease the radiation quality of the tubes.

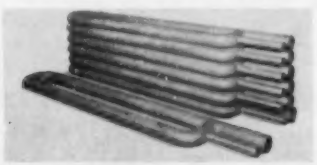
The very high water cooling rate and the swift rotation of the mold compress the molten metal against the mold surface and result in a uniform tube and finer grain size. Quality of castings produced on permanent molds eliminates the old sand defects encountered in using the sand line mold method.

Centrifugally cast tubes produce a more homogenous structure which results in more economical machining.

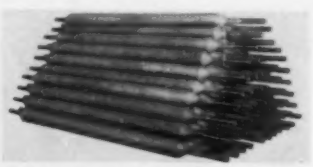
Uniform wall thickness to limit of ± 0.010".

Lower tooling on special size molds. The perfect balance which is obtainable by the use of permanent molds results in a very smooth operation which in turn eliminates the concentric ring defects or banding.

Short deliveries can be effected due to the flexible and simplified manufacturing processes.



Misco "Centricast" Radiant Tubes are efficient furnace heating elements. Made from centrifugally cast tubes with static cast U bends.



5" O.D. Misco "Centricast" Furnace Conveyor Rolls, centrifugally cast bodies with flash welded ends. Misco Metal 36% Ni—16% Cr.

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MISCO *One of the World's Pioneer Producers of Heat and Corrosion Resisting Alloys*
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Continuous, dependable automatic control . . .
with the

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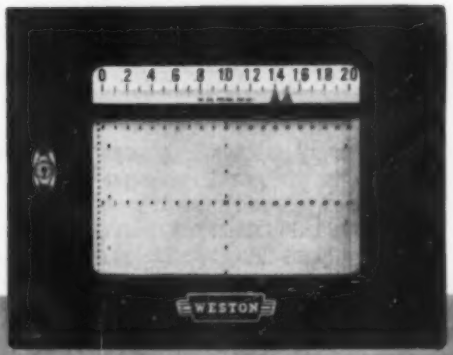
RECORDER-CONTROLLER



UNITIZED* design

features
relays that
never break!

***UNITIZATION:**

the grouping of related components — in Daystrom-Weston Potentiometer Recorders — in the simplest, most serviceable, most efficient manner.

DAYSTROM-WESTON'S basic potentiometer instrument design is supplemented by an exclusive control mechanism in the recorder-controller version. By using a minimum of parts —and keeping them compact, yet easily accessible—the advantages of DAYSTROM-WESTON UNITIZATION are brought to this controlling instrument. The results: an extra dividend in reliability and simple efficiency . . . in the most compact recorder-controller offering guaranteed ¼% accuracy.

Control settings are quickly and accurately made. Maintenance is simplified by the integration and interchangeability of key parts. And the control circuit offers unequalled sensitivity and dependability. Live circuits are NEVER BROKEN . . . they are ALWAYS MADE! The circular track contacts—with patented tumbler switch and gap design—permit response adjustments down to zero differential. A single screw makes the change. Proportioning control—as well as on-off control—is available in the standard instrument.

You see at left, details of the unitized control panel . . . including the exclusive contact-switching unit. In most other respects, this instrument is identical in construction, and offers the same advanced performance and maintenance features as the DAYSTROM-WESTON SINGLE-POINT and MULTI-POINT RECORDING POTENTIOMETERS.

For full information on any of these instruments, call your local WESTON Representative, or write to WESTON Instruments, Division of Daystrom, Inc., Newark 12, N. J. In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 10, Ont. Export: Daystrom Int'l., 100 Empire St., Newark 12, N. J.

DAYSTROM-WESTON

A DAYSTROM UNIT

Industrial Instruments

Canadian Letter . . .

promise significant improvement over existing techniques or equipment or be of particular importance to Canada. Furthermore it should be well suited to Canadian resources and our capabilities to make effective use of them.

Aside from the major activities in the study of conventional weapons, work on corrosion at NRE and PNL covers practically all aspects of the problems. One achievement is the cathodic protection of the underwater steel. Magnesium alloy anodes are successful but electrolytic processes for the prevention of scale in sea-water circulating systems also show great promise.

J. T. N. Atkinson of NRE has discovered a radically new method of electroplating copper on aluminum, whereby cheaper and lighter aluminum conductors, easily soldered, may be manufactured. The only preparatory treatment required is degreasing. The bath consists of citric acid, copper sulphate and a soluble fluoride such as potassium fluoride. (Copper can also be deposited from oxalate solutions.) Typical plating adhesion values exceed 2000 psi. in shear.

The bulk of our metallurgical research is carried out in a dozen or more Canadian universities. Research grants have been made for studies in physical metallurgy, for example, in fields concerning the role of dislocations in work hardening and age hardening mechanisms and in the elucidation of the early stages of the tempering reactions. Other studies have centered on boron steels, in an attempt to clarify the hardenability effect of boron. Still other grants are financing studies on crystal boundary segregation and mobility of grain boundaries, in the hope that a better understanding of recrystallization and grain growth may result.

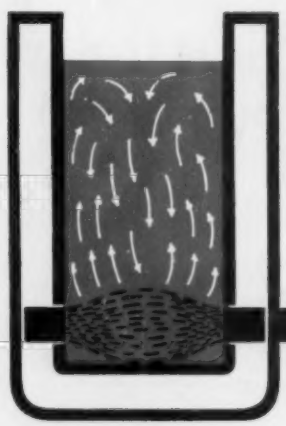
Various other projects include studies of hydrogen content of high-tensile steels which exhibit the phenomenon of delay fracture, and the behavior of stainless steel in acid solutions saturated with carbon monoxide gas.

Another group of problems have to do with guidance systems for missiles. For example, the photochemical properties of single crystals of thallium sulphide are being investigated. This material is of great interest in solar batteries. Manganese-carbon alloys containing various other elements (such as aluminum, indium, or gallium) have potential use in communication equipment and in low-temperature control devices. Other projects concern ceramic and tantalum electrolytic capacitors.

Finally, an interesting project carried out for Defence Research Board by the Ontario Research Foundation concerns a new material called controlled-density steel. It is produced by direct reduction of iron oxide to a spongy mass of iron which is then rolled to various densities. Effects of density, alloying elements and heat treatment on mechanical properties have been determined and parts produced.

Although the amount spent by DRB on sponsored materials research in Canada is only a small fraction of that spent in the United States, many achievements have already resulted. A large percentage of Ph.D. graduates in metallurgy and other sciences have also benefited from these research grants, to which their degrees are in some part owing. This is an achievement in itself.

Defence Research Board
H. P. Tardif



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XXVI

This is the twenty-sixth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Cold-Finishing of Alloy Steels: The Cold-Drawing of Bars

Cold-finishing of alloy bars may be divided into two general categories: (1) cold-drawing, where the bars are pulled through a die with no surface removal; and (2) turning and grinding, which removes the surface. We shall consider the cold-drawing procedure in this discussion.

Cold-drawing is the process of pulling a pickled and limed bar through a die, which results in a bright, smooth finish of the section, combined with close tolerances. The alloy bars are prepared for cold-drawing by pickling in a hot solution of dilute sulphuric acid for removal of scale. This is followed by a water rinse, and immersion in a hot lime-water bath to neutralize the effects of the acid, and to aid in carrying special liquid lubricants into the die.

Alloy bars may be cold-drawn under four conditions: *as-rolled*, *normalized* (low-carbon grades only), *annealed* (lamellar or spheroidized), or *quenched and tempered*. These conditions are determined by the grade of alloy steel, the resultant hardness, and the mechanical properties desired for a given end use.

In cold-drawing, the alloy bar is machine-pointed, to reduce the size at one end so it will pass easily into the die opening. Otherwise, the bar is pushed or extruded into the die by an auxiliary device. A die-holder, which can be made to contain from one to four dies, is mounted in an appropriate head assembled across a "draw bench," so that from one to four bars can be drawn at the same time. The draw bench has a bed which accommodates a 4-wheel buggy with jaws that grip the pointed ends of the bars as they emerge from the dies. The buggy has a hook on one end which engages an endless chain, thus pulling the bars through the dies for their entire length.

After cold-drawing, each bar feeds automatically into a straightening machine, and is sheared or "cracker-cut" to length on appropriate machines. Saws are used when the cross-sections of the bars are too large to be cracked or sheared, or when clean square ends are required.

Smaller sizes in the form of coils are drawn on "bull-blocks," or "wire-blocks," depending on sizes, followed by straightening and cutting on special machines.

Specifications with respect to chemical composition, grain size, hardenability, and the like, of cold-drawn alloy steels have been given long study by Bethlehem metallurgists. If you would like suggestions on cold-drawn products, or any other problem concerning alloy steels, our metallurgists will be glad to give you all possible help, without cost or obligation on your part.

In addition to manufacturing the entire range of AISI alloy steels, Bethlehem produces special analysis steels and the full range of carbon grades.

If you would like reprints of this series of advertisements, please write to us, addressing your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa. The subjects in the series are now available in a handy 40-page booklet, and we shall be glad to send you a free copy.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

Personal Mention

Franz P. Zimmerli

FRANZ P. ZIMMERLI, one of the outstanding authorities on spring metallurgy and automotive springs, retired in January after more than 30 years with the Barnes-Gibson-Raymond Div., of Associated Spring Corp. in Plymouth, Mich. During his years with the company, his technical contributions have helped Associated Spring attain a position as the leading manufacturer of precision mechanical springs.

After receiving a B.S. and M.S. degree in chemical engineering from the University of Michigan, Zimmerli spent a year as an instructor in chemical engineering at the University before turning to the industrial field. He went to work as a metallurgist for the Solvay Process Co. in Detroit in 1921, but a year later the automotive industry claimed his interest and he joined Dodge Bros. as a research metallurgist and later Rickenbacker Motor Co. as chief metallurgist. In 1926 he began his career with Barnes-Gibson-Raymond Div. as chief engineer at the Detroit plant (which moved to its present location in 1951) and in 1955 was appointed director of research for Associated Spring Corp.

The American Society for Metals recognized his achievements in the metallurgical field in 1947 when the Albert Sauveur Achievement Award was presented to him for his basic research on surface stress, upon which a great deal of the later studies of surface stress was based. He was also the William P. Woodside lecturer in 1951. Although many other technical societies claim his membership, he is perhaps most active in the Society of Automotive Engineers, where he has served as a councilor of the society since 1955.

With Mr. Zimmerli's retirement from the Plymouth installations, all research activities will be shifted to the company's headquarters in Bristol, Conn., where a new research center was recently completed. Succeeding him as director of research will be **H. Perry Smith** who has supervised the establishment of the new research facilities since joining the corporation as assistant director of research in 1957.

D. Cameron Perry has been promoted from research engineer to senior research engineer in the research division of Armco Steel Corp., Middletown, Ohio. Mr. Perry joined Armco in 1941, rising to junior metallurgist in 1949 and research engineer four years later.

Chester A. Tudbury has been named chief engineer of the New Rochelle Tool Corp., New Rochelle, New York. Mr. Tudbury formerly spent 16 years with the Ohio Crankshaft Co. as a research engineer for the Tocco Div., specializing in high frequency.

David G. Rowland, after receiving his master's degree from Iowa State College late last year, joined the applied research laboratory of U. S. Steel Co., Monroeville, Pa., as an assistant technologist in the sheet products division.

William F. Pravel has been named supervisor of toolsteel development in the application and development department of Allegheny Ludlum Steel Corp., Pittsburgh. A staff member at Allegheny-Ludlum since 1934, he was district manager for tool sales in Chicago for ten years before coming to the corporate office in Pittsburgh in 1957 on special assignment.

Alfred B. Wells has succeeded **M. J. McKeever** as branch manager of the Atlanta, Ga., sales branch of Crucible Steel Co. of America. Since 1952 Mr. Wells has been assistant branch manager. Mr. McKeever, a charter member of the Georgia Chapter, has been with Crucible in Atlanta since 1927 and will remain with the branch as special sales representative.

John H. Corson, former manager of the Carpenter Steel Co. research laboratory, recently became manager of the company's Webb Wire Div. in New Brunswick, N.J. He joined Carpenter in 1952 as a metallurgist and since 1954 has been manager of the research laboratory.

L. William Kates has been appointed director of engineering of Sylvania-Corning Nuclear Corp., the new company formed last year by Sylvania Electric Products Inc. and Corning Glass Works in Bayside, L.I., N.Y. Joining Sylvania Electric in 1947 as an engineer, he was named engineering manager when Sylvania's atomic energy division was organized, and in 1956 became manager, commercial development.

Isaac R. Wood recently joined LaSalle Steel Co., Chicago, in a sales development capacity, following 17 years as a metallurgist in the materials process engineering department of the Frigidaire Div. of General Motors Corp.

Michael A. LaPorte has been promoted to general supervisor, metallurgical control, strip mills and agricultural products, at the Midland, Pa., works of Crucible Steel Co. of America. Mr. LaPorte joined Crucible in 1940 at the Midland metallurgical laboratory and since 1957 had been metallurgist.

B. R. Nijhawan, director of the National Metallurgical Laboratory, Jamshedpur, India, has been given the award of "Padma Shri" by the president of India in recognition of his "exceptionally distinguished service in the fields of science in India".

Stanley A. Agnew, a member of the physical metallurgy research laboratories of the Canadian Dept. of Mining and Technical Surveys for the past seven years, has joined the Lehigh University faculty as an instructor in metallurgy.

"Here's the news we promised you"

FANSTEEL

TANTALUM SHEET

IS NOW AVAILABLE

FROM STOCK

For the first time since the beginning of its commercial production, Fansteel Tantalum Sheet is now available from "on hand" warehouse stocks.

With our new Muskogee, Oklahoma plant now in production, and our expanded processing and fabricating facilities at North Chicago in full operation, we can make delivery of unannealed sheet from stock—annealed sheet within two weeks.

If you are now using tantalum or are planning its use in your product, you can count on Fansteel to deliver tantalum in any form or shape—on time to meet your production schedules.

And you can count on Fansteel quality. Our completely integrated production, with strict quality control in all of the steps from the processing of the ore to the finished metal, guarantees you the finest quality tantalum.

IMMEDIATE DELIVERY ON THESE FIVE MOST USED SIZES
.002"
.003"
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WE'LL RUSH YOU PRICE BULLETIN

Call, wire or write for new price bulletin just released. Contains complete prices for both tantalum stock items and special mill runs.

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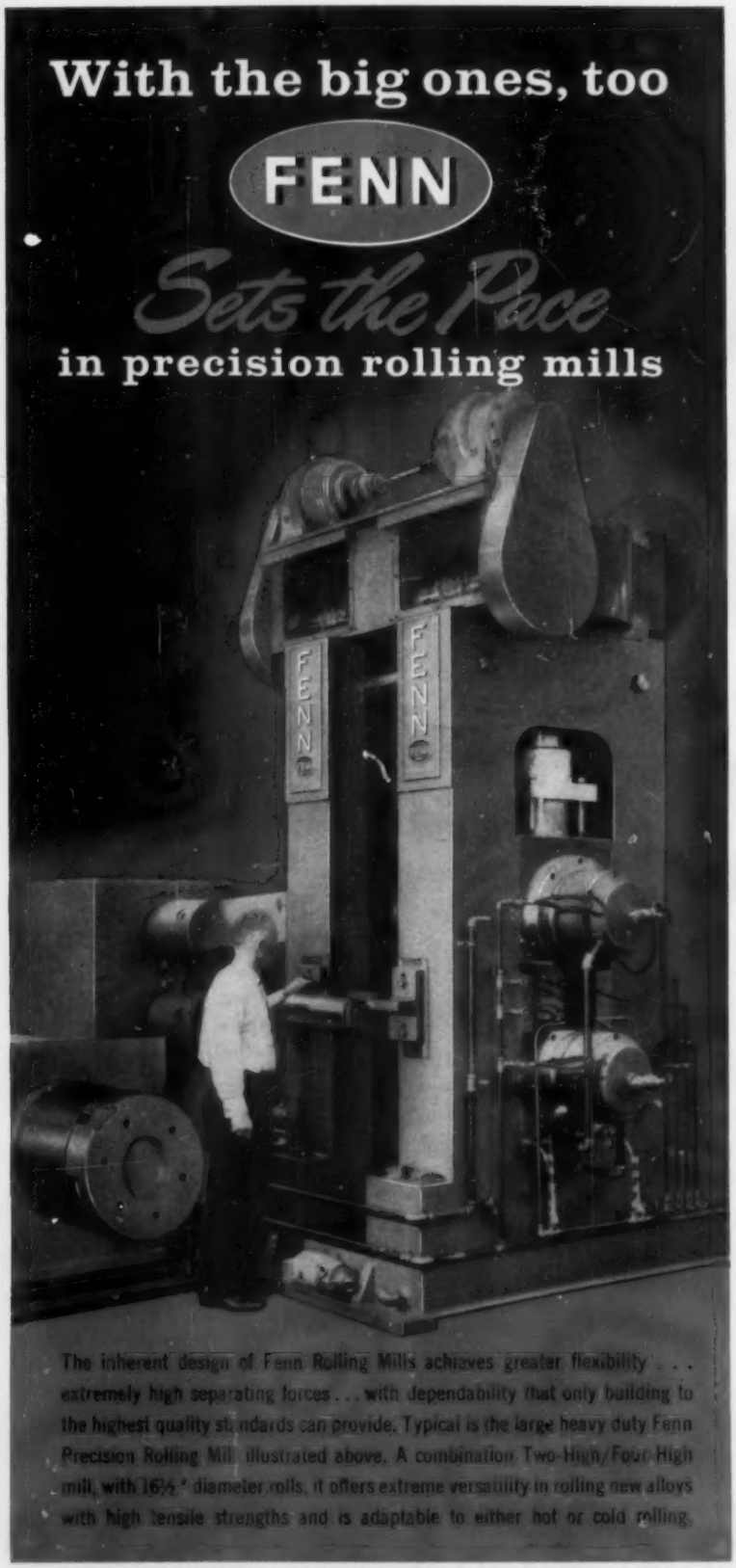

With the big ones, too
FENN
Sets the Pace
in precision rolling mills
FENN
FENN
The inherent design of Fenn Rolling Mills achieves greater flexibility . . . extremely high separating forces . . . with dependability that only building to the highest quality standards can provide. Typical is the large heavy duty Fenn Precision Rolling Mill illustrated above. A combination Two-High/Four-High mill, with 16½" diameter rolls, it offers extreme versatility in rolling new alloys with high tensile strengths and is adaptable to either hot or cold rolling.
THE FENN MANUFACTURING COMPANY • 503 FENN ROAD • NEWINGTON, CONN.

Personals . . .

Robert A. Kokat and **Gerald R. Garinger** have assumed new responsibilities with the Carpenter Steel Co., Reading, Pa. Mr. Kokat, who joined Carpenter as a sales engineer in the Philadelphia area in 1943, has been promoted from assistant branch manager to branch manager of the Philadelphia operations. Mr. Garinger has been named assistant branch manager of the Toledo, Ohio, mill-branch warehouse. He had supervised the new Toledo warehouse since its completion in January 1957.

Victor G. Goodell is currently manager of the new branch warehouse of Crucible Steel Co. of America in Grand Rapids, Mich. Before his promotion, he was a sales service engineer working out of the Detroit branch.

R. P. Lutz has been transferred from the Sandia Corp., Albuquerque, N.M., to the Western Electric Co., parent company of Sandia Corp. Mr. Lutz, formerly vice-president, operations, with Sandia, will take over as director of research and development at the new research and development laboratory being organized by Western Electric in Princeton, N.J.

W. E. Kuhn has been assigned to the research and development division of the Carborundum Co., Niagara Falls, N.Y., as supervising engineer, metallurgy department.

Victor L. Baltzell, field representative for Oakite Products, Inc., in Dallas, Tex., for 15 years, has been named manager of the recently established mid-South division of Oakite in Louisville, Ky.

J. H. Dasdorf has left his position as metallurgical engineer with Shultz Steel Co., Los Angeles, to accept a similar position with Earle M. Jorgenson Co. in Los Angeles.

Lewis W. Berger has joined the rapidly expanding staff of the Metals Engineering Institute of the American Society for Metals as training supervisor. Before coming to Cleveland, Mr. Berger was principal metallurgist in the nonferrous physical metallurgy division, Battelle Memorial Institute, Columbus.

April—Ammonia storage tank installed without supervision by supplier "Z"...

Later—Leaks! Getting improper flow of ammonia . . .

Still later—Discovered certain vital equipment improperly installed . . .

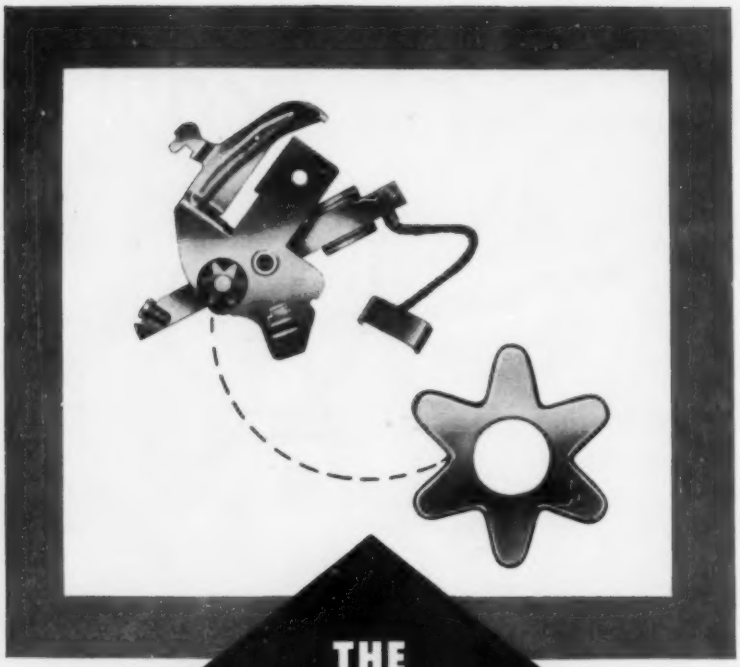
Too late—Safety and efficiency at danger point, shut down line to make repairs . . .

Be trouble-free—be sure Armour Ammonia experts help supervise <u>your</u> cylinder and storage tank installations!

Armour's Technical Service plus a consistent purity of 99.98%—on delivery—from 163 stock points and 8 bulk stations make Armour your one best source for trouble-free ammonia. For further information on cylinder or storage tank installations, write us on your company letterhead.

ARMOUR AMMONIA DIVISION

1353 West 31st Street • Chicago 9, Illinois



THE
CIRCUIT BREAKER
THAT WOULDN'T BREAK...

till Miller Phosphor Bronze took over!

There's phosphor bronze . . . and then there's *Miller Phosphor Bronze*. A leading manufacturer of circuit breakers learned the difference the hard way. Designers used phosphor bronze in the star spring of the circuit breaker shown above . . . but spring pressure wasn't uniform, and breakers often failed to open under an electrical overload.

Miller—whose specialty is phosphor bronze—experimented with various alloys and tempers for the phosphor bronze spring until they came up with the right material for the job. They specified Miller Grade A Phosphor Bronze—a material that met the rigid requirements for the job . . . was highly corrosion-resistant . . . and was *less* expensive than the phosphor bronze originally used!

Only specialists in phosphor bronze like Miller can get to the bottom of your application problems so quickly.

miller
SINCE 1849

ROLLING MILL DIVISION
THE MILLER COMPANY
MERIDEN, CONN.

. . . WHERE PHOSPHOR BRONZE IS THE MAIN LINE—NOT A SIDELINE

Personals . . .

Charles Frederick Reinke has been assigned to the metallurgy division of Argonne National Laboratory, Lemont, Ill., as a chemical engineer. Mr. Reinke comes from Windsor, Conn., where he was an irradiation coordinator for Combustion Engineering, Inc., New York.

Michael Zetz has been appointed superintendent, quality and production controls at Jones & Laughlin Steel Corp.'s new stainless sheet and strip mill now under construction in Louisville, Ohio. Mr. Zetz has been associated with J&L's stainless steel division since January and before that time was employed at Crucible Steel Co. of America's Midland, Pa., plant where he was division metallurgist in charge of melting and bar products.

Oliver E. Shipp has become affiliated with Sam Tour & Co., Inc., and the American Standards Testing Bureau, Inc., New York, as a consultant. His headquarters will be in Newburgh, N.Y.

B. J. Higgins, until recently employed by the Sylvania-Corning Nuclear Corp. in Hicksville, L.I., N.Y., has taken a position with Small Tube Products, Inc., Altoona, Pa.

David H. Duff, Jr., has transferred from the materials engineering section of Everett & Lynn Foundries in Fitchburg, Mass., to the foundry department where he is manager of product engineering.

David W. Levinson has been advanced to assistant manager of the metals research department at Armour Research Foundation of Illinois Institute of Technology. He has been on the Foundation staff since 1953, last serving as supervisor of nonferrous metallurgy.

Paul R. Brucker has been appointed to the newly created position of plant metallurgist for Crucible Steel Co. of America, Midland, Pa. In his new capacity, he will direct all metallurgical activities in the flat rolled products, melting, and bar products divisions of the Midland works. Mr. Brucker joined Crucible in 1935 and was division metallurgist, flat rolled products, for the past two years.

60 CYCLE INDUCTION MELTING

Melting metals in the 60 cycle induction furnace will bring greater economy and quality to your melting and casting operations. Whether you produce zinc or aluminum die castings, brass or bronze castings, ductile iron castings, or aluminum extrusions — to name but a few fields — there is an induction furnace to do your job.

60 cycle induction melting will reduce metal losses to a minimum and eliminate metal contamination. Alloy composition is maintained uniformly, and metal temperature is closely controlled at all times. Operating conditions are ideal: worker fatigue is reduced significantly.

AJAX ENGINEERING CORPORATION has specialized in just this one field: building the best and most efficient 60 cycle induction melting furnace for the job. As pioneers of this melting principle we have accumulated considerable experience in each field of application.

AJAX induction furnaces have been instrumental in establishing new metallurgical processes such as continuous casting, continuous galvanizing, and aluminum coating of steel. Exclusive AJAX developments are the electromagnetic pump and the AJAXOMATIC for controlled pouring.

AJAX 60 cycle induction melting furnaces range in size from 20 kw to 2000 kw, produce from 150 pounds per hour up to 40 tons per hour.

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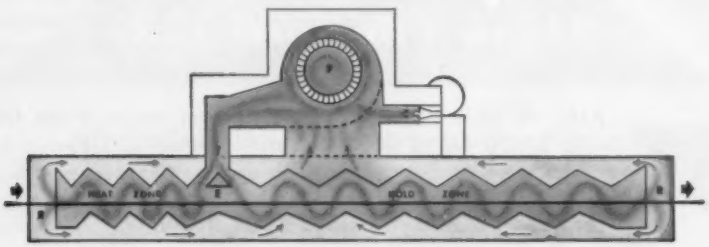
AT ± 5° F.

Industrial's "Circ-Air" tempering furnace is the most efficient heating machine ever designed.

The turbulent recirculation of hot gases through and around the work insures maximum and uniform heat transfer. Proper channeling of the hot gases to the work prevents wasteful dissipation of heat; and puts heat where it is needed — on the work.

A "Circ-Air" processing 2000 lbs. per hour at 1300° F., holding ±5° F., forces 14,500 C. F. M. of hot gases through the work. "Circ-Air" heating is recirculation at its best.

The continuous "Circ-Air" is suitable for heating steel, brass, aluminum and cast iron at temperatures up to 1450° F.



WHY THE CIRC-AIR IS THE BEST TEMPERING FURNACE!

The work is carried on a continuous conveyor. Loading can vary; ¼" bolts are densely loaded up to 3" deep. Less dense loading may be 20" deep. A 3' x 21' "Circ-Air" tempers over 2000 lbs. per hour.

Hot gases from the combustion chamber "C" and recirculated gases returning from the work chamber mix in the fan area "F." Entering the heating area through "T" at control temperature, balanced heat is directed to the charge and discharge ends, and is returned to the mixing chamber. The continuous V construction of the metal liner forces the hot gases up and down through the load at high velocity. The hot gases in the heating zone flow counter to the work. Heat transfer is rapid. Equilibrium is reached at point "E", and ±5° F. is held the length of the holding zone. Heating is without temperature head.

"Circ-Air" furnaces have been built in widths up to 108 inches, in lengths up to 165 feet, for temperatures from 250 to 1450° F., and capacities from 200 to 16,000 lbs. per hour. *Send for Bulletin 13-A*

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HEATING EQUIPMENT CO.

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PIONEERS AND STILL LEADERS IN RECIRCULATION

Personals . . .

R. E. Groethe has joined the staff of the metallurgical department of Jessop Steel Co., Washington, Pa. For the past nine years, he was manager of the metallurgical department, Corning Glass Works, Corning, N.Y., and prior to that was a metallurgist in the steel and tube division, Timken Roller Bearing Co.

Peter Payson and **Walter L. Finlay** have been reappointed by the National Advisory Committee for Aeronautics to the Subcommittee on Aircraft Structural Materials. Both men are concerned with research at Crucible Steel Co. of America, Mr. Payson as assistant director of research in charge of the central research laboratory in Pittsburgh, and Dr. Finlay as manager of the Midland, Pa., research laboratory.

Henry C. Ashley has been named metallurgical director at the Chase Metal Works plant of the Chase Brass & Copper Co., Waterbury, Conn., a subsidiary of Kennecott Copper Co. Associated with Chase since 1934, he has held positions as research assistant, metallurgical engineer, and more recently as assistant metallurgical director for the company.

Harry W. McKee and **Edgar C. Knop** have been assigned new duties with the Crucible Steel Co. of America's Chicago branch. Mr. McKee, who formerly was office and warehouse manager, now directs the activities of the branch's home sales force as assistant branch manager, staff, and continues to be responsible for the Chicago office and warehouse. In his new capacity as assistant branch manager, field, Mr. Knop will coordinate the work of the supervisors and salesmen in the field. He was supervisor of stainless steel sales before this promotion.

C. P. Dillon has been transferred to the Institute, W. Va., plant of Union Carbide Chemical Co., as materials engineer in the engineering department. Mr. Dillon, corrosion group leader at the Carbide Texas City, Tex., operations since 1950, joined the organization in 1941 as a laboratory assistant at the South Charleston, W. Va., plant.

"PARK-KASE GIVES US TOP QUALITY CRAWLER TRACTOR PARTS... CUTS HEAT TREAT COSTS 50%"

William J. Blazek, President, Evans Reamer and Machine Company, a manufacturing division of Lempco Automotive, Inc., Cleveland, says, "QUALITY must be the watchword around here because Lempco's replacement parts go into practically every type and make of crawler tractor. These parts have got to be good to meet the challenging requirements of this great tractor industry.

"On track bushings, for example, correct heat treatment is essential to the quality of the product—and costs must be in line.

"After a great deal of investigation, we decided that the high quality of Lempco's bushing could best be achieved effectively through the use of salt bath heat treatment. We selected Park-Kase No. 2 Energizer for the salt bath operation. It has never let us down.

"More than 19 different-sized track bushings—all with different wall thicknesses—all made from low carbon steel—are carburized at 1750 deg. F. in Park-Kase. There is also the economy of a direct quench in an 8% brine solution maintained at 70 deg. F. by refrigeration. Bushings are fully case-hardened to the required accepted standards. Case depths up to 0.110 in., depending upon wall thicknesses involved, are readily obtained in our salt bath heat treatment.

"We have achieved the top quality in these replacement parts that we must have. We have done this at a saving in cost of 50% over the previous heat treat methods. In fact, salt consumption and costs are lower than even the pre-installation estimates.

"To make a long story short, we must have quality and economy in this operation. Park Chemical Company more than satisfies our requirements."

For complete data on Park-Kase No. 2 Energizer write for technical bulletin A-1. Park Chemical produces a complete line of heat treating materials and would be happy to help you work out a solution to your heat treating problems without obligation. Call or write today.

Evans Reamer and Machine Company uses Park-Kase Energizer #2 to case-harden track bushings up to 0.110" case depth. Inspecting track bushings that have been case hardened are (l. to r.): from Evans: Lynn M. Leslie, Production Manager; LeRoy L. Johnson, Superintendent; William J. Blazek, President; from Park Chemical's Cincinnati Office, James F. Hetz.

Park

Woodside Rapid Carburizers (Non-Burning—Charcoal—Coke—Specification) ● Park-Kase Liquid Carburizers ● Quenching and Tempering Oils ● Cyanide Mixtures ● Neutral Salt Baths ● High Speed Steel Hardening Salts ● Iso-Thermal Quenching and Tempering Salts ● Protective Coatings (No-Carb—No-Kase—No-Scale—No-Tride) ● Carbon Products (Charcoal—Crushed Coke-Pitch Coke—Lead Pot Carbon) ● Kold Grip Polishing Wheel Cement ● Par-Kem Metal Cleaners ● Cutting and Grinding Compounds (Kem-Cut—Kem-Grind—Blue Ice)

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Personals . . .

August B. Kinzel, vice-president in charge of research for Union Carbide Corp., New York, has begun his year term as president of the American Institute of Mining, Metallurgical, and Petroleum Engineers. During the past year, Dr. Kinzel has held the office of president-elect and director of A.I.M.E. He has been actively engaged in research work with Union Carbide since 1926 when he joined the Electro Metallurgical Co. as a research metallurgist.

William H. Jahns is now manager of the Orange County Auto-Truck Lease Co., and in addition, represents Rex Precision Castings.

Dudley D. Gallup has been transferred from Philadelphia where he was district manager of sales for G. O. Carlson, Inc., Thorndale, Pa., to Chicago as district manager of sales.

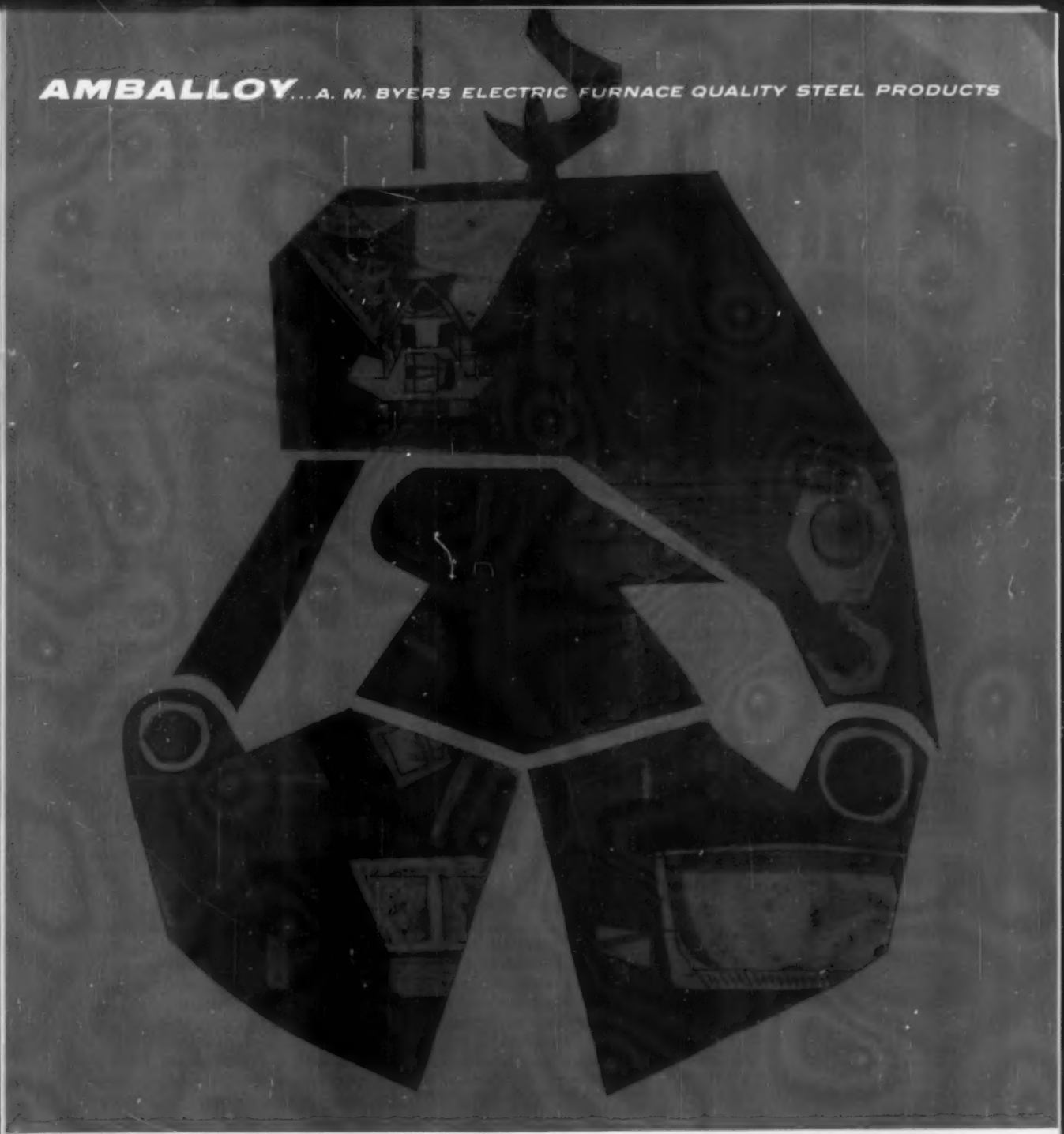
Otto Zmeskal has been named dean of the University of Toledo college of engineering. He had been a research professor in the college of engineering at the University of Florida since 1954, and is currently conducting research on the oxidation of zirconium for the U. S. Atomic Energy Commission. In addition to his duties as dean, he will continue to serve as consultant to the Oak Ridge National Laboratory.

Raymond J. Severson has been transferred as manager to the newly established branch of Ampco Metal, Inc., in Garland, Tex. Mr. Severson, as assistant general sales manager of Ampco, conducted surveys of Southwest markets which were instrumental in the company's decision to establish the Garland branch.

Raymond F. Parker has been promoted to manager of cutting tool sales in the metallurgical products department of General Electric Co., Detroit. Mr. Parker joined the department (formerly Carboloy Dept.) in 1945, and before his promotion was manager of mining sales.

Julian D. Carey, Jr., has left the General Electric Co., York, Pa., where he was a metallurgical engineer in the welding department, to accept the position of welding engineer in the York, Pa., division of Borg-Warner Corp.

AMBALLOY... A. M. BYERS ELECTRIC FURNACE QUALITY STEEL PRODUCTS



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The combination of manganese, molybdenum, copper and boron—alloyed with steel in proper balance and proportion—results in great strength and high fatigue resistance. This alloy is available now in hot rolled plates and bars which can be heat treated to several hardness ranges.

Automotive, mining, agricultural, earth moving and conveyor equipment are just a few of the end-product applications where BYLOY wears so well. Call in the Byers metallurgist for information on BYLOY, or any of the other electric furnace steels we produce. Write: A. M. Byers Company, Clark Building, Pittsburgh 22, Pennsylvania.

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FREE
TEST SAMPLE KIT

A free, no-obligation, lab analysis on your blastcleaning efficiency. See where your money goes. **No Cost to you.**

Result? More durable structure, greater resistance to breakdown, longer life, greater cleaning ability, lower abrasive costs, lower maintenance costs, faster cleaning.

®PERMABRASIVE is better than steel shot and grit because it contains more cutting carbides producing a much, much faster cleaning time; add its lower price and you have an obvious savings in costs!

®PERMABRASIVE is better than ordinary annealed shot and grit because it has more cutting carbides and less graphitic carbon—because it has less phosphorus content indicating a resistance to breakdown—and because the cutting carbides are held in a unique ductile matrix; this means a much, much longer abrasive life with an obvious savings in costs!

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"Using (blank) annealed abrasive, the consumption per wheel-hour was 18.4 lbs.; with PERMABRASIVE the consumption was 14.7 lbs. . . . a reduction of 20.1%."

"We checked the performance of PERMABRASIVE vs two brands of Steel Shot. Results:

PERMABRASIVE . . . $.81, Steel Shot—Brand A . . . $1.48, Steel Shot—Brand B . . . $1.04."

"Used PERMABRASIVE in test against mixture of Steel and Annealed Shot. Abrasive cost per wheel-hour with PERMABRASIVE was $.93, against $1.17 for the mixture . . . a savings of 20.5%."

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WRITE DEPARTMENT S-A

Personals . . .

John A. Henricks has accepted a post as development engineer with Allied Research Products, Inc., Baltimore.

William J. Collins has been promoted to the position of manager of metallurgy at the Corning Glass Works, Corning, N.Y., succeeding **R. E. Groethe** who has resigned to join the Jessop Steel Co., Washington, Pa. Mr. Collins has been on the staff of the company's metallurgical department since 1951, and until his current assignment served as supervisor of precious metals.

Donald J. McPherson has been chosen to replace **Robert A. Lubker** as manager of the metals research department at Armour Research Foundation of Illinois Institute of Technology. Mr. Lubker resigned recently to accept a post as director of research at the Alan Wood Steel Co., Conshohocken, Pa. Formerly assistant manager of the metals department, Mr. McPherson was an associate metallurgist at Argonne National Laboratory, Lemont, Ill., until joining the foundation in 1950.

Jack G. Conner is currently a project engineer at Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, working on the development of beryllium and beryllium alloys for air force structural applications.

William H. Santschi has joined the Beryllium Corp. of Reading, Pa., as associate director of research. For the past seven years, he had been supervisory metallurgist with Allegheny Ludlum Steel Corp.

Joseph J. Warga has taken a position as development engineer with Aerojet-General Co., Sacramento, Calif., a division of General Tire and Rubber Co. For the past four years he was chief metallurgist, Steel Products Engineering Co., Springfield, Ohio.

John E. Fogarty has transferred to the Massillon, Ohio, plant of the Republic Steel Corp. where, as stainless development metallurgist, his duties will involve the development and processing of high-strength, high-temperature stainless steel strip.

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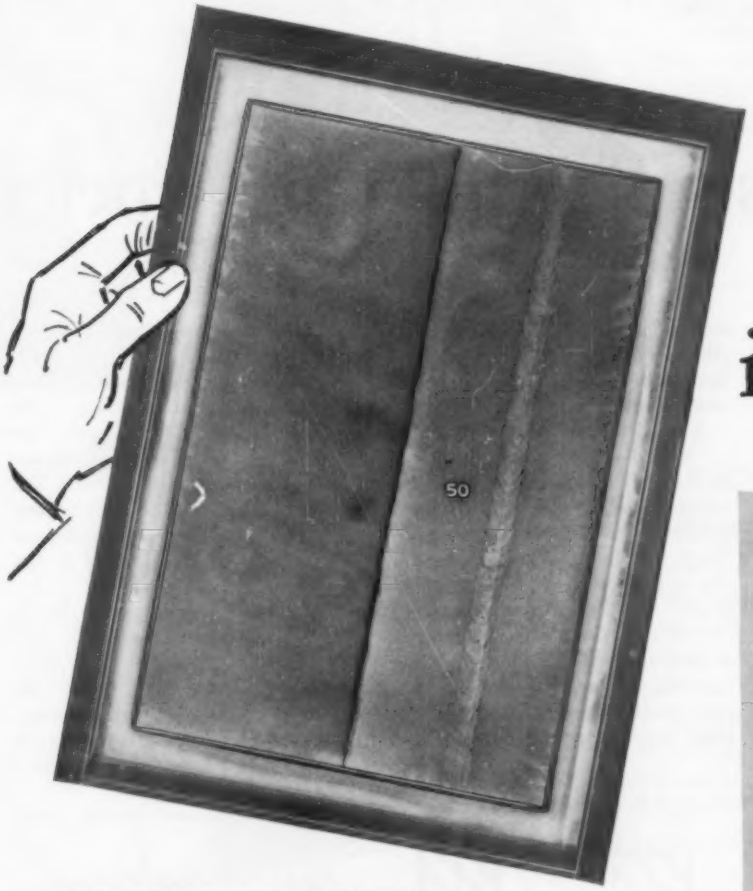
100% x-ray inspection



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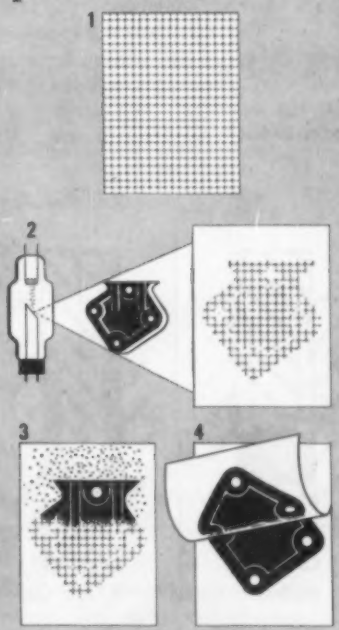
...ends time and cost of x-ray film processing

If you want to perform 100% inspection of light-metal or thin-section ferrous components—xeroradiography (zero-radiography) is *the* preferred method. *Within one minute after exposure, you can view results* well within the accepted 2% sensitivity. Corrections can be made immediately after a flaw is detected.

As for cost saving — xeroradiography requires a less expensive installation. There's no darkroom . . . no x-ray film. Metal plates are re-usable.

If you've been wanting to institute 100% x-ray inspection, General Electric now offers you a process that overcomes previous time and cost factors. Ask your G-E x-ray representative to demonstrate xeroradiography's possibilities for you. Or write X-Ray Department, General Electric Company, Milwaukee 1, Wisconsin, for Pub. AS-44.

How xeroradiography process works...



1. Aluminum plate, coated with photo-sensitive selenium, receives positive charge which is lost when exposed to x-rays.

2. X-rays penetrate specimen as in conventional radiography. Charge on plate "leaks" away in direct proportion to the degree of x-radiation.

3. Negatively charged powder from spray gun adheres to positively charged area. Density varies with amount of charge. Image can be viewed directly, copied on film record, or transferred to paper.

4. Print can be made by pressing special paper on plate by rollers. Powder from plate is transferred, giving a positive image which is fixed permanently by applying heat. Plate is cleaned for re-use.

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Digests of Important Articles

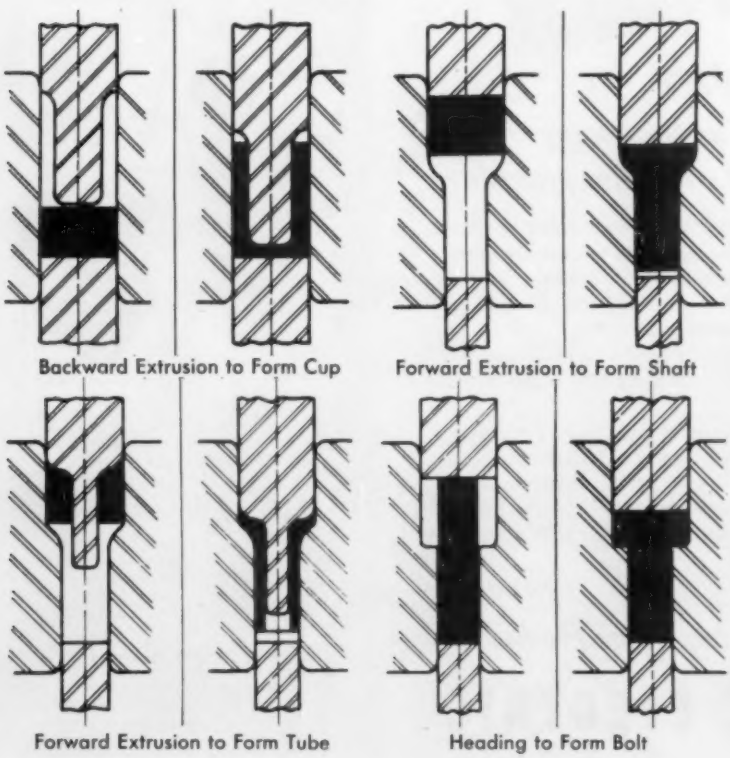
Cold Working of Metals at Ford

Digest of talk by D. J. Davis, vice-president, manufacturing, Ford Motor Co., before the Detroit Chapter, Society of Automotive Engineers, Feb. 17, 1958.

FOUR BASIC cold forming methods are used in production (Fig. 1) today. The first, backward extrusion, gives cup-like objects from a solid slug. The slug is enclosed in a die, and a moving punch causes it to extrude back along the punch. A second method is forward extrusion. Here, a cylindrical pre-form is forced through a throated die of suitable cross section to form a stepped shaft.

A third method is a modification of forward extrusion to form a tube. In this case, the punch is shaped to maintain an internal cavity. Stepped tubular parts can be formed. A fourth method is an expansion of the well-known cold heading technique: A rod or wire is upset in a closed die to form a flange or head at one end. By combining these methods, it's possible to build up a process sequence to form accurately many types of parts.

Fig. 1 – Four Cold Forming Methods in Production Today

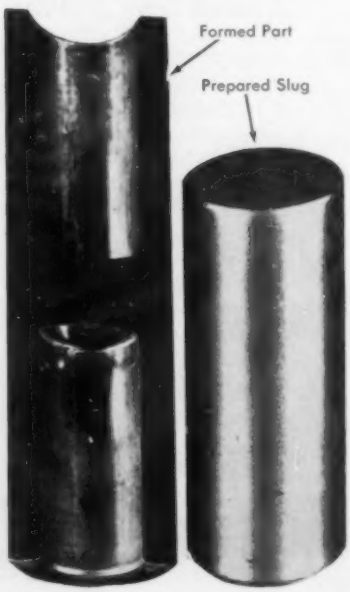


Several factors are responsible for today's increased use of cold forming. Improved lubricants have made it possible to reduce friction in the forming operation. Formerly, the amount of extrusion that could be done in a single operation was limited by the life of the lubricant. Now, the metallurgy of the die and the material being formed is the limiting factor.

Increased metallurgical know-how is making it possible to cold work steels containing higher carbon or more alloy. Also, better die materials and improved design allow forming of a greater variety of shapes and have helped in automating the process.

The cold extrusion process has a

Fig. 2 – The First Production Application of Cold Forging at Ford Was the Piston Pin. More than 20,000,000 have been produced in the last three years



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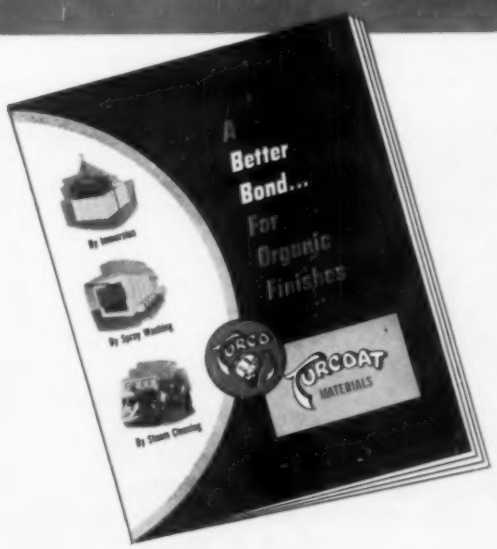

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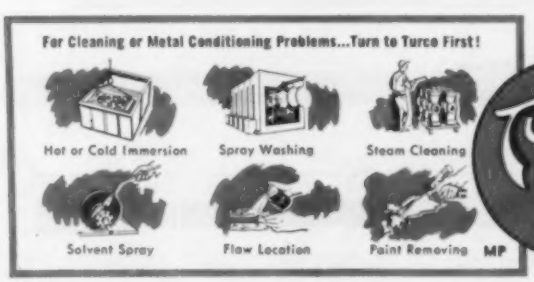

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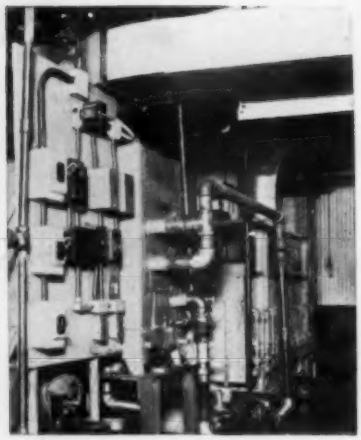
Manufactured in Canada by B. W. Deane & Co., Montreal
Offices in all Principal Cities



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***quickly* pulls down the initial peak load of heat in quenching... and saves cooling water**

● You gain in accurate control of quench bath temperatures and quickly effective capacity to handle initial peak load of heat in quenching. You prevent production set-backs, increase the output of your heat treating department, prevent oil fires, save losses from rejected parts.

Niagara *Aero* Heat Exchangers give you this control in both furnace and induction hardening methods. They prevent both over-heating and over-cooling of the quench bath. Hundreds of heat treaters know they prevent many troubles, constantly improve quality and increase production.

They quickly pay for themselves by saving cooling water coils and extend your quench capacity without extra water or cooling tower.

Write for Bulletins 120 and 132 giving complete information.

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District Engineers in Principal Cities of U. S. and Canada

Cold Working . . .

number of advantages: Compared with hot forging, parts can be cold formed to closer and more consistent dimensions. No surplus stock is needed to compensate for scaling and decarburizing losses. Compared to machining from bar stock, cold forming to close dimensions also eliminates stock allowances here. Thus, a significant amount of material is saved by the process.

Reduced machining requirements is another advantage. Investment in machines (such as automatic screw machines) is less, cutting tool costs are lower. Design limitations due to difficulty in machining some critical contours and radii are reduced, since these areas can be cold formed to finish dimensions.

Substantial improvements in physical properties also result from the cold forming technique. For example, it gives an improved grain flow that does not outcrop into machine fillets and radii, as often happens in the case of forgings and bar stock.

Cold forming increases the strength of metals; for many parts heat treating can be eliminated. Also, a good surface results (there are no tool marks). This minimizes the need for grinding and other expensive surface finish treatments.

The first production application of cold forming at Ford was the piston pin in Fig. 2. More than 20,000,000 have been produced over a period of three years. Less than ⅛ lb. of steel is required for each pin, compared with nearly ¾ lb. needed for the previous screw machine process.

The cold formed pins have better engineering properties, compared to machined pins. In fatigue tests, cold formed pins averaged over 51,000 cycles to failure, while machined ones failed after 15,500 cycles.

In making the piston pin, four slugs (called pre-forms) are cut simultaneously from bar stock to an exact weight. This is a critical step; if the pre-form does not contain enough metal the finished part will not be completely formed. If the pre-form contains too much metal, it can break the dies, since they completely enclose it. The weight tolerance allowed in forming this ⅛ lb. slug is ½ g. (about the weight of a paper clip).

The next step is lubricating the slug. Baskets loaded with pre-forms are revolved through a phosphate solution. This is followed by the application of a metallic soap.

The pins are formed by a double-backward extrusion process in which the punches enter both ends of the slug at the same time. Finished pins are knocked out of the die onto the conveyer. Engine tappets are also being made by cold extrusion.

Another cold formed part in pro-

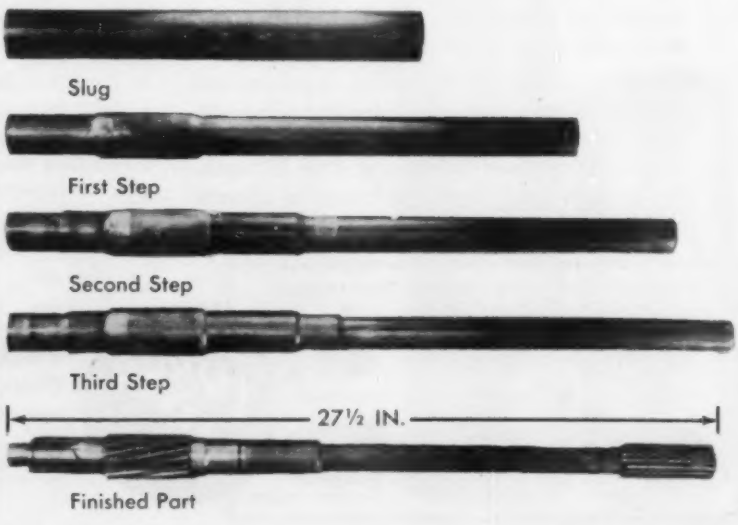

Fig. 3 — Steps in Extruding a Shaft. The process involves a series of hits, each designed to form one portion of the stepped shaft. The spline teeth are cold formed rather than machined to finish the part

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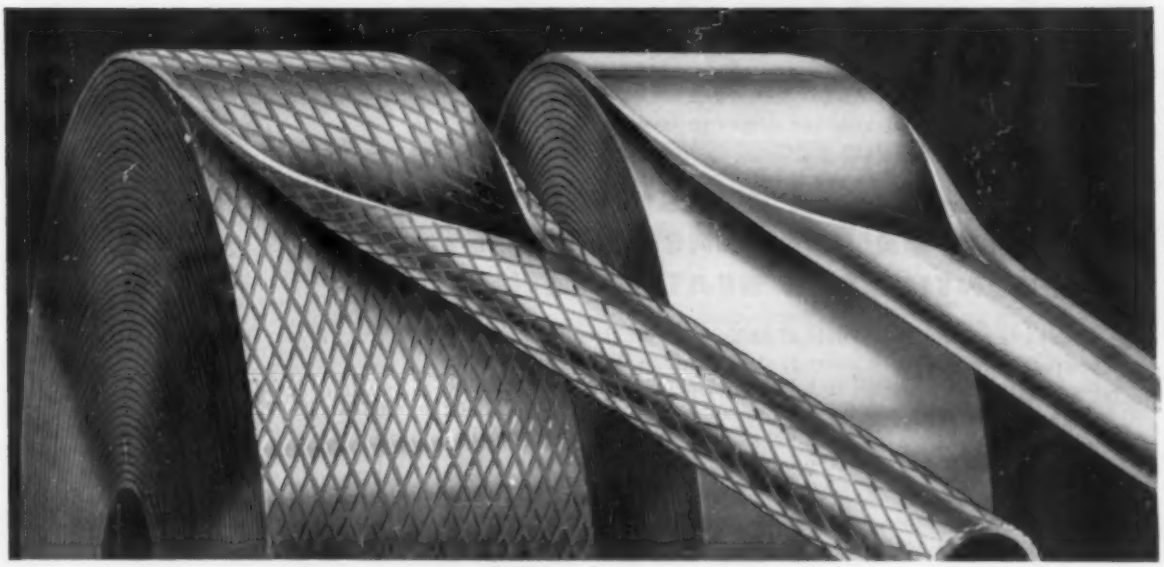

Quaker State Metals Company, leading fabricator of aluminum building products, recently installed a 25 kw, 450,000 cycle TOCCOtron vacuum tube oscillator for continuous welding of aluminum tubing. Both plain and patterned strip, anodized or untreated according to end-use requirements, is continuously welded. Diameters vary from ½" to 1" O. D. and wall thicknesses from .024 to .064".

The weld is absolutely uniform throughout the entire length, assuring a dependable, strong bond. The whole operation is so smooth and quiet, you hardly know it's running.

Aside from the perfect weld, for the ultimate in product quality, TOCCO Induction Welding, being a completely automatic process, saves time and money over many conventional joining methods.

Remember, whether *your* products are of ferrous or non-ferrous metals, TOCCO can almost certainly save *you* time and money in heat-treating, brazing, welding, or hot forming operations.

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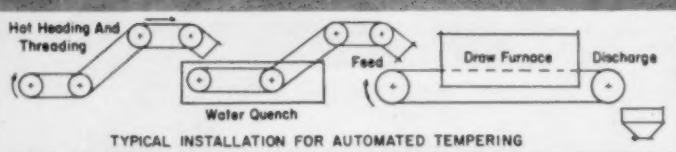
Cambridge WOVEN WIRE BELTS



TYPICAL INSTALLATION FOR AUTOMATED TEMPERING

METAL-MESH BELTS RESIST WARPING OR BUCKLING—CUT COSTS IN CONTINUOUS HEAT TREATING

Moving thousands of pounds of bolts per hour through 1150° F. temperatures is a cinch for rugged Cambridge Woven Wire Belts because they're designed to take high temperatures with a minimum of operating trouble and maintenance. And, open mesh construction assures high product uniformity. Furnace heat flows through the belt and around product for fast, thorough processing.

In cleaning, brazing, oiling and quenching operations, too, Cambridge Belts help increase production and maintain high product uniformity. Here's how:

CONTINUOUSLY MOVING BELTS ELIMINATE BATCH PROCESSING—give faster, less costly production; reduce slow, costly manual handling.

ALL-METAL CONSTRUCTION IS HEATPROOF, COLDPROOF, ACIDPROOF—Cambridge Belts can be woven from any metal or alloy to take sub-zero or up to 2100° F. temperatures, yet remain impervious to attack from water, acids or caustic solutions.

OPEN MESH PROVIDES FREE AIR, LIQUID CIRCULATION—gives more uniform heating, cooling, drying; permits flash drainage of solutions, rapid washing, quenching and cleaning.

SPECIAL SURFACE ATTACHMENTS AVAILABLE—raised edges or cross flights to hold product on belt during movement.

Talk to your Cambridge Field Engineer soon—he'll explain the many advantages of continuous heat treating on Cambridge Woven Wire Belts. He'll recommend the belt size, mesh or weave—in the metal or alloy—best suited to your operations. You'll find his name in the classified phone book under "BELTING, MECHANICAL". Or write for FREE 130-PAGE REFERENCE MANUAL giving mesh specifications, design information and metallurgical data.

The Cambridge Wire Cloth Co.

WIRE CLOTH | METAL-MESH CONVEYOR BELTS | WIRE CLOTH FABRICATIONS

Department B, Cambridge 4, Maryland

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

Cold Working . . .

duction at Ford is a truck wheel nut. It is formed by a two-step extrusion process. In the first step, the pre-form is cold headed to increase the diameter of the blank at the extrusion end. In the second step, it is extruded forward to form the nut, backward to form the barrel, and upset to form the flange. This job illustrates how parts may be made by using various combinations of cold forming methods. In this case, Ford eliminated a costly screw machine process as well as a milling operation on the square end of the nut.

Another part being made in production quantities is a tractor power take-off shaft (Fig. 3). Cold forming increases tensile strength, yield strength, and hardness. The improved properties given by the process makes it possible to meet the engineering requirement of Brinell range of 286 to 321 without heat treating. The same basic process used in making the tractor shaft can be used for a number of other parts.

Splines can be cold formed too, rather than machined. Splines on seven production shafts are being formed by the cold rolling process. A shaft turned to the approximate pitch diameter of the spline is placed between two racks into which the spline form has been ground. By moving the racks in opposite directions, the shaft is rolled between the racks so that the teeth are pressed into the shaft. The metal thus displaced flows into the root spaces of the rack teeth and forms the spline.

In most cases the change from hobbing to rolling requires that part specifications be changed from straight-sided to fine-pitch involute spines. Fatigue tests of shafts with the rolled involute spline show considerable improvement in strength characteristics. This is due to the increased root diameter, the superior finish, the cold working of the metal surface, and the greater number of teeth.

Spline rolling has several other advantages over hobbing or other methods of machining. One is closer dimensional control. Splines can be produced to closer and more consistent tolerances by rolling than is generally possible by hobbing or shaping.

(*Continued on p.* 138)

USE FINKL DIE BLOCKS FOR QUALITY FORGINGS

... the automotive industry does!

An upstate New York forge shop specializes in the forging of crankshafts, knuckles, and other high production items used in automotive production. Because the volume of each particular forging is very high, it is possible to evaluate costs and study tooling very closely

In the illustration above, the manufacturer is using Durodi for both the blocking and finishing crankshaft impressions in this forging press operation.

Durodi, made by Finkl electric furnace quality steel practice is a high volume producer and a most practical hot work tool for close die forgings. It hardens deeply and uniformly, is resistant to abrasion and withstands both shock and impact loading at high hardness. Its Special Machining Quality also appreciably reduces sinking time. All of these advantages mean more production at less cost.

Finkl die blocks are available in several grades, all sizes and tempers to handle virtually any forging requirement. Call your local Finkl representative next time you are considering die blocks or forgings. He will be glad to help you and there is no obligation.

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Proof of Vulcan Tool Steel Superiority

Examining piercing punch of Vulcan Alidie High Carbon-High Chrome Tool Steel are Ralph Claypool, left, stamping foreman, Long Manufacturing Division, Borg-Warner Corp., and Tom Varley, right, Vulcan Sales Engineer.

35 ton Stoll Press die assembly enlarges and trims center holes in pre-hardened clutch plate.

REDUCES TOOL MAINTENANCE COSTS BY 87%...

Vulcan Alidie Tool Steel!

Vulcan sales engineers, cooperating with engineers of Long Manufacturing Division, Borg-Warner Corporation, reduced sharpening of die and punch tools from *once every 2 days to once every 15 days.*

Long Manufacturing Division produces clutch plates for commercial vehicles and industrial trucks. Pre-hardened material is SAE 1065, with a hardness of 41/46 Rockwell C. Thicknesses range from .040" to .090" x various diameters.

Costs and downtime were lowered because Vulcan engineers recommended the *right* steel for the job: Vulcan Alidie High Carbon-High Chrome Tool Steel with a hardness of 61/63 Rockwell C. This same engineering help is available to you without charge.

For the name of your nearest Vulcan representative, all you have to do is write, wire, or call collect: *Vulcan Crucible Steel Division, H. K. Porter Company, Inc., Aliquippa, Pa.*

H. K. PORTER COMPANY, INC.

VULCAN CRUCIBLE STEEL DIVISION

Cold Working . . .

Cold rolling requires less tool grinding and lower downtime. Also, investment in equipment is lower. For example, on one of the rear axle shafts being made at Ford, an eight-spindle rotary hobber, costing about $100,000, will produce 110 pieces an hr. The same part can be produced on a single station rolling machine, costing $27,000, at a rate of 300 pieces per hr.

Thus, with a facilities investment of only about 25% of that required for hobbing, the rolling method will increase productivity by almost 200%. In some cases, spline rolling racks have produced 1,000,000 pieces before grinding, compared to an average hob life of 3000 pieces. There is also a saving in material, and all chip handling and disposal problems are eliminated.

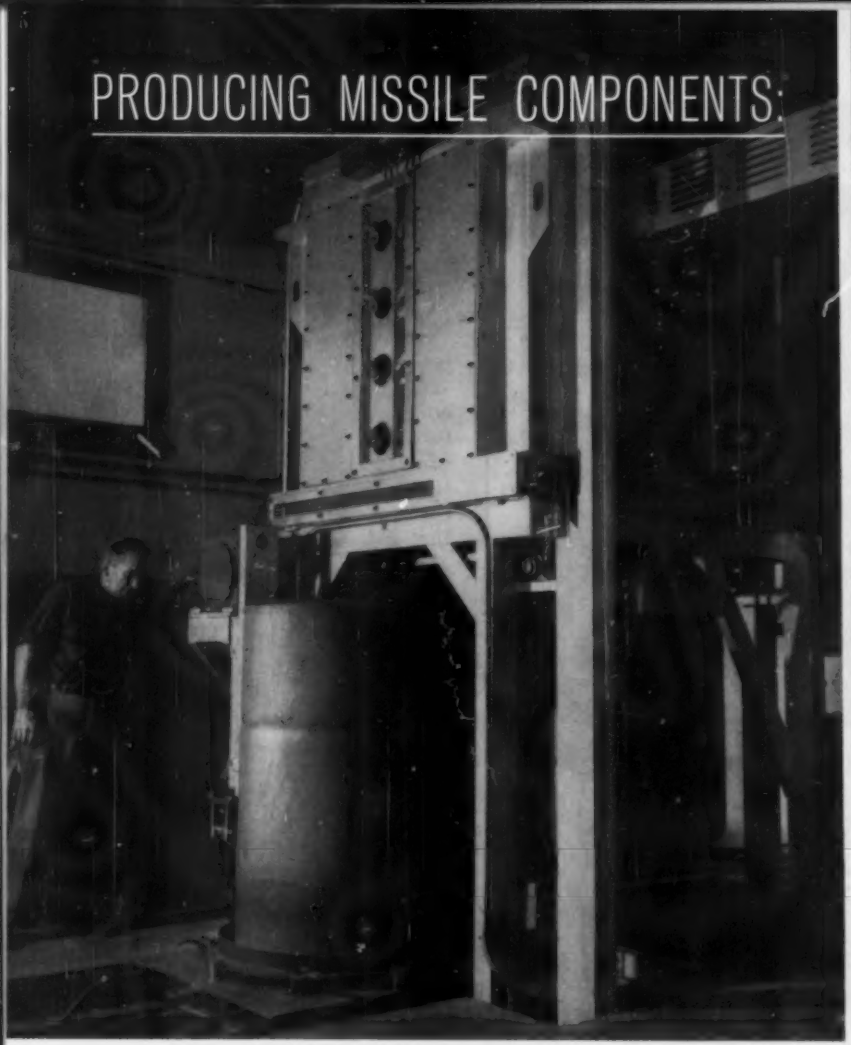
As refinements in steelmaking make cleaner and more workable steels available, it will be possible to use cold extrusion with more medium and higher alloy steels. Cold rolling will also be applied to an ever-greater variety of splines and other similar shapes. The improved grain flow and other desirable metallurgical properties will offer a real challenge to the design engineer. He will have the opportunity to take advantage of material properties never before utilized. A. G. G.

High-Strength Aluminum Casting Alloy

Digest of "High-Strength Aluminum Casting Alloy 40-E: D.T.D. 5008", by J. F. Gardner and M. R. Hinchcliffe, *Metallurgia*, Vol. 55, February 1957, p. 79-84.

ALLOY 40-E is an aluminum casting alloy (containing about 0.6 Mg, 5.5 Zn, 0.5 Cr, 0.20 Ti, 0.1 max. Cu, 0.5 max. Fe, 0.1 max. Mn, 0.25 max. Si) in which strength and other desirable characteristics may be developed without heat treatment. D.T.D. (Directorate of Technical Development, British Ministry of Supply) 5008, issued to most exacting requirements covers its use for aircraft components. The material combines high strength and toughness, excellent machineability, weldability, hardness, corrosion and

PRODUCING MISSILE COMPONENTS:



STAINLESS BRAZING PROBLEMS LICKED

By assembling inexpensively-produced components and then brazing them in this Harper Elevator Furnace, Fabriform Metal Products, Inc., Los Angeles, has by-passed high manufacturing costs. Forging, casting and excessive machining have been eliminated in producing a tremendous variety of complicated products . . . including stainless missile and jet engine parts.

Operated on a two-shift basis, the Harper Furnace has not only proved extremely versatile, but has enabled Fabriform to overcome many tough brazing problems. Even metal working dies and molds of tool steel have been copper brazed without decarburization. Recently, a thousand stainless steel bearing housings were copper brazed with only one reject in the lot. Relatively heavy sections of difficult-to-braze super alloys such as A-286 and Inconel X have been handled successfully. Excellent results have been obtained using a variety of base metals, as well as filler metals including nickel-base alloys.

With the furnace capable of holding a ton of parts stacked 30″ high within a 24″ diameter, temperatures up to 2100 F can be attained in the inconel retort. Temperature uniformity is excellent: Placed within loads 20″ high, matched thermocouples show no temperature differences.

"The Harper Furnace is extremely flexible and can produce practically any time-temperature cycle within reason," says A. M. Thompson, Gen. Mgr. of Fabriform. "Because we can hold effluent dew points of —90 F, it's possible to do extremely difficult jobs . . . We haven't had a forced shutdown since installation over three years ago."

To reap the maximum benefits of furnace brazing, you'll find it pays to talk to a Harper representative . . . for Harper can build the furnace best suited to your needs: box, pusher, mesh belt, roller hearth, bell, elevator or pit. For detailed information, write: Harper Electric Furnace Corp., 40 River St., Buffalo 2, N. Y.

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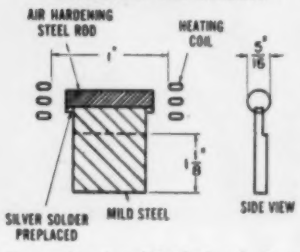
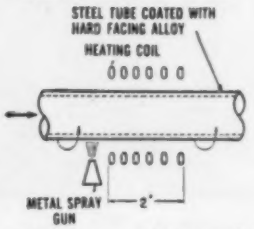
TYPICAL INDUCTION HEATING APPLICATIONS

SIMULTANEOUS HARDENING and BRAZING

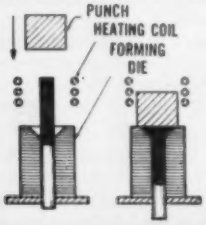


The machined and finished rod of air-hardening steel is simultaneously hardened and brazed to a mild-steel tab. Use of a purified hydrogen atmosphere and a high temperature brazing alloy permits successful hardening of alloy steels without discoloration and scaling even in the absence of flux.

DIFFUSION BONDING OF SPRAYED METAL COATINGS



Corrosion or wear resistant metal coatings sprayed on metal surfaces can be improved by heating to achieve alloying by diffusion. The drawing shows a typical arrangement for processing steel tube sprayed with hard facing alloy. Long tubes may be progressively sprayed and heated.



HEATING HIGH STRENGTH ALLOYS FOR FORMING

Uniform and rapid heating of high strength alloys (alloy steels, titanium, etc.) aids in upsetting and forming operations and also minimizes oxidation and embrittlement.

Electronic Tube Generators from 1 kw to 100 kw.
Spark Gap Converters from 2 kw to 30 kw.

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Casting Alloy . . .

stress-corrosion resistance, and good color. It does not overage at room temperature and may readily be anodized.

The mechanical properties of 40-E are relatively easy to reproduce. Composition is held within narrow limits, and impurity content kept to very low values. Optimum properties are obtained with 5.5% Zn and 0.6% Mg. Loss of strength results when these elements are lowered. Higher strengths with decreased elongation are obtained when the zinc and magnesium are too high. The alloy has an extended freezing range, 1140 to 1060° F., necessitating careful running and feeding.

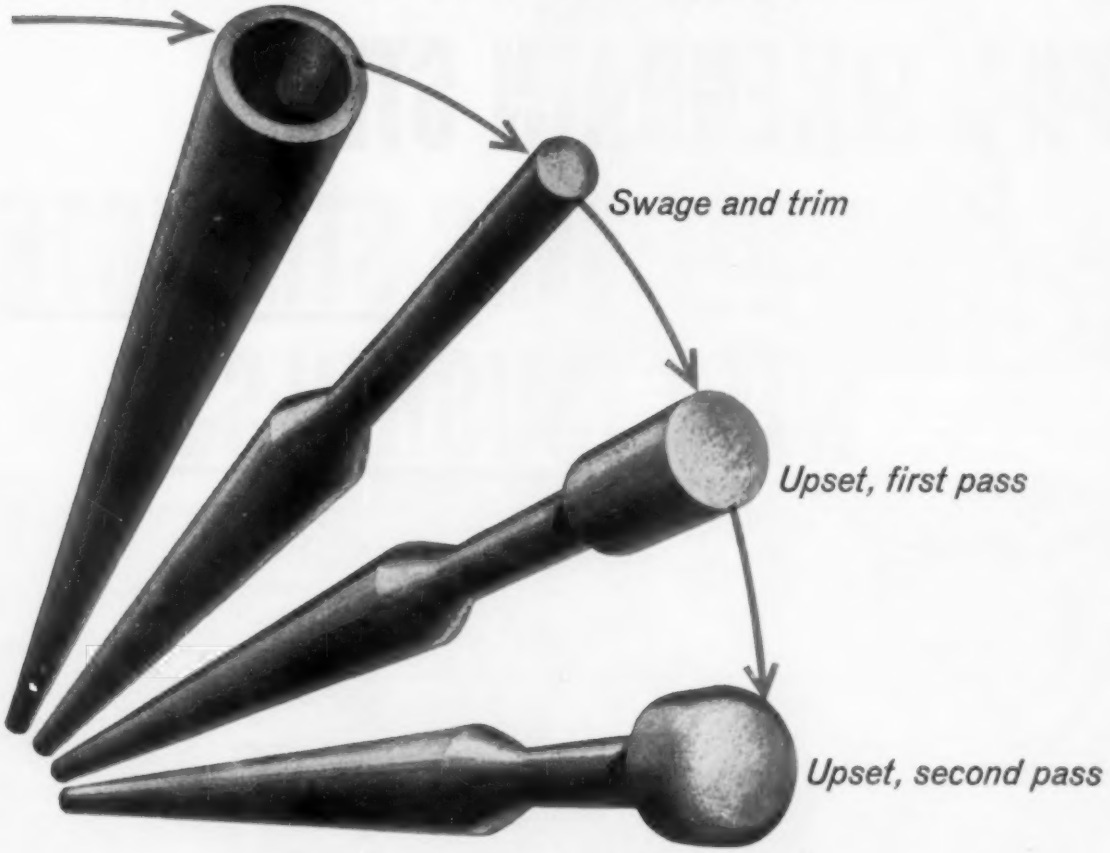
Alloy 40-E can be melted and poured satisfactorily by (*a*) never going above 1470° F. or dropping too close to the liquidus, which may result in chromium segregation; and (*b*) melting as rapidly as possible, under slightly oxidizing conditions, with ample covering flux, and gentle stirring. Degassing is best accomplished by slow scavenging with nitrogen. Magnesium losses run to 0.1% and should be made up by plunging preheated magnesium beneath the melt.

Shrinkage of 40-E alloy is relatively high, and ample feeding is necessary, particularly while the metal is passing through the low-strength pasty stage during solidification. A bright reflective surface is proof of a sound casting. A tendency to draw and tear has retarded the use of 40-E in die castings, but these difficulties may be overcome by the use of sand or shell molded cores, and by a properly integrated feeding system. In pressure die castings, allowances must be made for the comparatively low fluidity and high shrinkage of 40-E.

Top running of 40-E is preferred, to encourage progressive solidification. Top pouring is practicable if turbulence is minimized, because the alloy does not have strong dross-forming tendencies. Feeding gives more predictable results than chilling, but the form of feeding heads is critical. Insufficient feed prolongs solidification of the section and increases shrinkage, and massive feed retards cooling of the section with adverse effects. The use of

(*Continued on p. 144*)

Start with OSTUCO TUBING



and end up with a 34% *saving*

Here's a cost-cutting case history right in the Ohio Seamless mill. It proves we take our own medicine—*and like it.* You may, too.

Formerly, mandrels for rolling Ostuco Tubing on our Assel mill were made from two pieces. A shaped end, hogged out of solid bar stock, was welded to a long tube. Expensive to machine, weld and process.

We decided to *forge the mandrels entirely from Ostuco Seamless Steel Tubing.* In three steps—swage, upset and finish-form—we now produce better mandrels . . . ready for use without any machining whatsoever, *and save 34% over former processing methods.*

Chances are good that Ostuco Tubing is the right prescription for slashing your production costs, too. For expert advice, contact our nearest sales office or our plant at *Shelby, Ohio—Birthplace of the Seamless Steel Tube Industry in America.*

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For whatever you make . . .

N-A-X® FINEGRAIN STEEL DELIVERS STRENGTH WITH TOUGHNESS

No more dramatic test of a steel's combined strength and toughness could be devised than the kind of job performance which Caterpillar Tractor Co. builds into its products.

As Caterpillar equipment literally moves the earth, bulldozer blade surfaces and scraper bowl bottoms must stand up to gruelling punishment. In these critical components, Caterpillar standards for steel are of the highest. N-A-X FINEGRAIN steel meets those standards with the right combination of strength with toughness.

And to this manufacturing operation, like so many others, N-A-X FINEGRAIN brings other important benefits as well. For example, the excellent weldability of N-A-X FINEGRAIN steel makes it exceptionally adaptable to Caterpillar's exacting requirements.

Review these salient advantages for your job: N-A-X FINEGRAIN steel, compared with carbon structural grades, is approximately 50% stronger • has high fatigue life with great toughness • is cold formed readily into difficult stampings • is stable against aging • has greater resistance to abrasion • is readily welded by any process • offers greater paint adhesion • polishes to a high luster at minimum cost. And the physical properties of N-A-X FINEGRAIN are inherent in the "as rolled" condition. N-A-X FINEGRAIN'S resistance to normal atmospheric corrosion is twice that of carbon structural steel.

NOTE: Where greater resistance to extreme atmospheric corrosion is an important factor, our N-A-X HIGH-TENSILE is recommended.

For whatever you make, from tractors to pressure cylinders, with N-A-X HIGH-STRENGTH steels you can design longer life, and/or less weight and economy into your products.

This bowl bottom assembly of the Caterpillar No. 470 Scraper requires numerous individual welding operations in its manufacture. Not only the parent metal, but the welds themselves, must have strength with toughness. Again, N-A-X FINEGRAIN *steel proves its excellent weldability.*

Here Caterpillar Earthmoving Equipment pushes America's great highway program forward. A Cat® DW 21 and matching No. 470 Scraper lead the way. The Cat DW 21 is assisted by a Caterpillar-built crawler Tractor.

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STEEL from Wheelock, Lovejoy BULLETIN

W-L CHICAGO Now in an ideal position to supply HY-TEN "M" Temper in large forged flats up to 6 x 22″, rounds to 18″ and squares to 17¼″. Also "B" No. 3-X in large forged flats to 6 x 13″, rounds to 18″ and squares to 16″. Alloy forgings a specialty.

W-L DETROIT The new, larger warehouse and office here have greatly speeded up delivery on our orders and services in this area. Have a good stock of A-8620 on hand as well as all HY-TEN grades.

W-L CLEVELAND The rolls for this Vaughn Four-Roll Continuous Pointer are fabricated from HY-TEN "M" Temper, nickel-chromium-molybdenum oil hardening steel. This Pointer, largest of its type in the world, can point rods ranging from ½″ to 1¼″ dia. HY-TEN "M" was selected by the machine manufacturer because it can be quenched and tempered to high hardness levels while retaining considerably greater toughness than would be possible with most other steels.

W-L CINCINNATI Another new and larger warehouse recently opened here. Same-day service on all sizes, shapes and grades of HY-TEN, plus our usual help on metallurgical problems.

W-L HILLSIDE, N. J. This W-L warehouse has an excellent stock of HY-TEN "B" No. 3-X in rounds, flats and squares. Same-day delivery is promised. Many of the larger sizes of forged rounds are rough turned.

W-L CAMBRIDGE HY-TEN "B" No. 2 is still a great favorite in New England for parts requiring medium duty and high quality at a reasonable price. Our research and development assure better HY-TEN specials — "the standard alloy steels of tomorrow."

W-L BUFFALO New HY-TEN "B" No. 3X-40 now available here in rounds ½″ to 8¼″ and hexagons 1¼″ to 2¾″, heat treated to 300 Brinell. Machines as easily as heat-treated 4140 leaded, but less expensive. Suitable for flame or induction hardening — tough and shock resistant.

Write our Cambridge office today for your *free* Wheelock, Lovejoy Data Sheets. They'll give you complete technical information on grades, applications, physical properties, tests, heat treating, etc.

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Casting Alloy . . .

separate exothermic feed sleeves is advisable, providing an adequate volume of metal which remains liquid longer than the casting. Keeping the pouring temperature reasonably high reduces shrinkage, but adversely affects feeding. If a section solidifies before the mold is filled, the shrinkage is not compensated because of the interruption of mass feeding, resulting in patches of drawn and porous metal. Mass feeding during the pasty stage, rapid filling, and pre-igniting exothermic sleeves are methods of overcoming this difficulty.

Green sand molds with careful control of sand conditions are preferred for sand foundry production. Either green sand cores or hard cores with rapid burn out properties are advisable to avoid excessive restriction of the contraction of the metal.

Shell mold castings, gravity die castings, and pressure die castings have all been successfully produced.

W. V. WARD

Corrosion and Abrasion Effect on Ferrous Metals

Digest of "Effect of Alternate Corrision and Abrasion on Some Ferrous Metals", by J. Dearden and J. D. Swindale, *Journal of the Iron and Steel Institute*, Vol. 185, February 1957, p. 227-234.

THE CORROSION RATE of ferrous metals exposed to the atmosphere decreases with time. This is due to partial protection from rust. However, periodic removal of the rust by rolling, abrasion and hammering will greatly increase the rate of corrosion. Inasmuch as corrosion reduces the resistance of a surface to abrasion, rolling and hammering, there are grounds for the belief that the resistance of ferrous metals to corrosion or abrasion may be very different if the two are alternated or combined. Since these two factors determine the life of numerous industrial components, it was decided to test a number of ferrous metals under various conditions ranging from pure abrasion to pure corrosion.

Eleven ferrous metals were tested: panel steel, Cor-Ten, normalized carbon spring steel, hardened carbon

(*Continued on page* 148)

a fascinating new book—

MAN, METALS AND MODERN MAGIC

by Dr. J. Gordon Parr

It has been a long road from the first accidental smelting of ore by a caveman's fire to the calculated fission of a uranium atom. But this 8,000 year history now has a most entertaining, conversational and sometimes humorous guide in Mr. Parr's new book *Man, Metals and Modern Magic.* He points out vividly the day and the way the Bronze Age became a fact; he shows, too, the historical and commercial effects of the time when iron became a war-waging necessity. In later chapters you can follow the alchemist in his search for a *philosopher's stone* and the first scientists in their efforts to discover facts about the properties of metals.

Manufacturing too is traced from its beginnings in home industries to today's giant sprawling fabricating plants. Until only a hundred years ago a country with resources of iron, copper, zinc, lead, tin, and coal could fill its needs and feed its people. But today aluminum, manganese, magnesium, zirconium, titanium, and uranium—to name but a few—are metals of prime industrial importance . . . a fact which Mr. Parr credits with shaping the lives of people and molding the destinies of nations.

In concluding this well-illustrated and fascinating account of man's experience with metal, author Parr draws back the curtain and projects the reader into yet another era – the day when the last iron has been smelted and the last lead recovered – the day when man will again live *without* the magic of metal.

This is a book for technician and student alike to enjoy—a story of metallurgical progress through the ages to the challenging problems of science that must be solved tomorrow.

15 Chapters . . . 44 Illustrations . . . 235 Pages . . . $2.95
Red Cloth Binding . . . Published April, 1958

The American Society for Metals

Egyptian use of bronze began a long history of metal experimentation. One of 44 illustrations.

Today's use of high strength alloys opens many doors into a new era in metals.

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HEAT

1. BRIGHT ANNEALING furnace reduced many machining costs.

FROM GENERAL ELECTRIC CAN CUT COST, IMPROVE QUALITY OF YOUR PRODUCT, TOO

General Electric furnaces speed production, cut rejects, reduce maintenance costs in hundreds of processing jobs. Your decision to call G-E heat experts *now* can save you money today and for years to come.

Nearly any product, like those shown at left, can be made better and at less cost through a heat processing modernization plan set up by General Electric. The savings you realize can pay off the initial cost of the system in two to three years—you get extra profits in years to come, cost-savings and a more saleable product today.

Here are four examples of the results achieved through the use of G-E heat processing equipment (pictured below):

1. SAVINGS OF 25 TO 50% in the manufacture of high quality stainless steel parts were realized as a result of bright annealing in General Electric furnaces in a Midwest heat treating plant. Two years of high-speed processing with virtually no maintenance and with low operating cost have resulted in high investment return and improved products.

2. PICKLING WAS ELIMINATED by bright brazing stainless steel parts in a General Electric semi-continuous tubular retort furnace. Bright, shiny parts of high quality are now produced in less time, at lower cost.

3. 75% SHORTER ANNEALING CYCLES—malleable-iron annealing with automatically-controlled General Electric roller-hearth furnaces cut cycle from 4 days to 48 hours, cut man-hours 40% for a Midwest concern. Straight-line, continuous annealing boosted process rate to 32 tons of high-quality castings every day and eliminated heat-up and cool-off time formerly required by old oil-burning furnaces.

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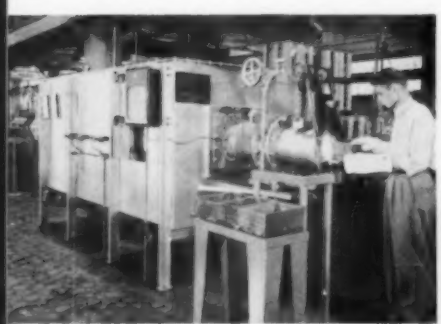

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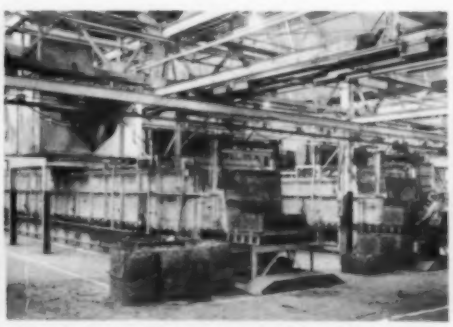

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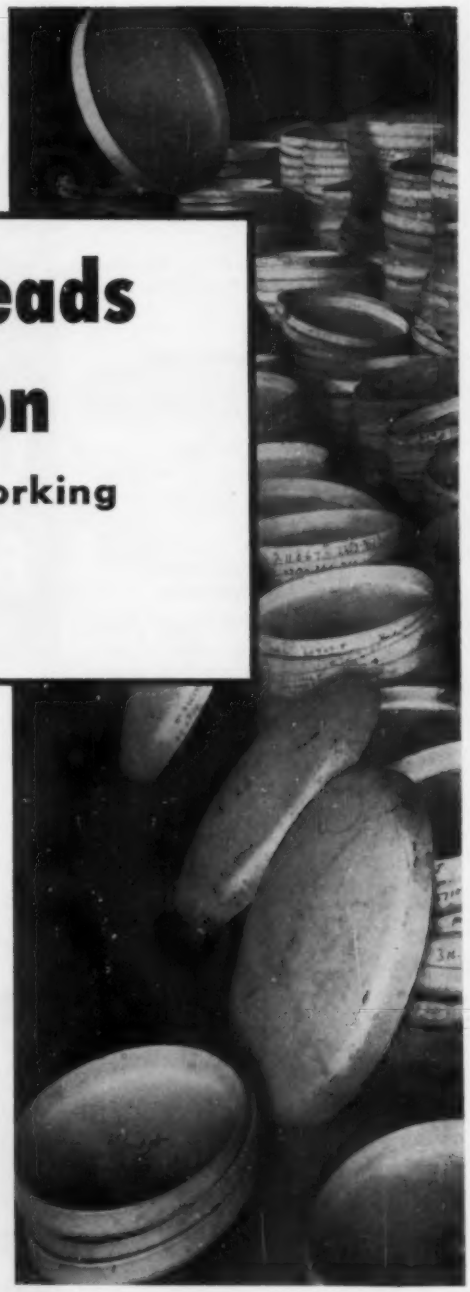

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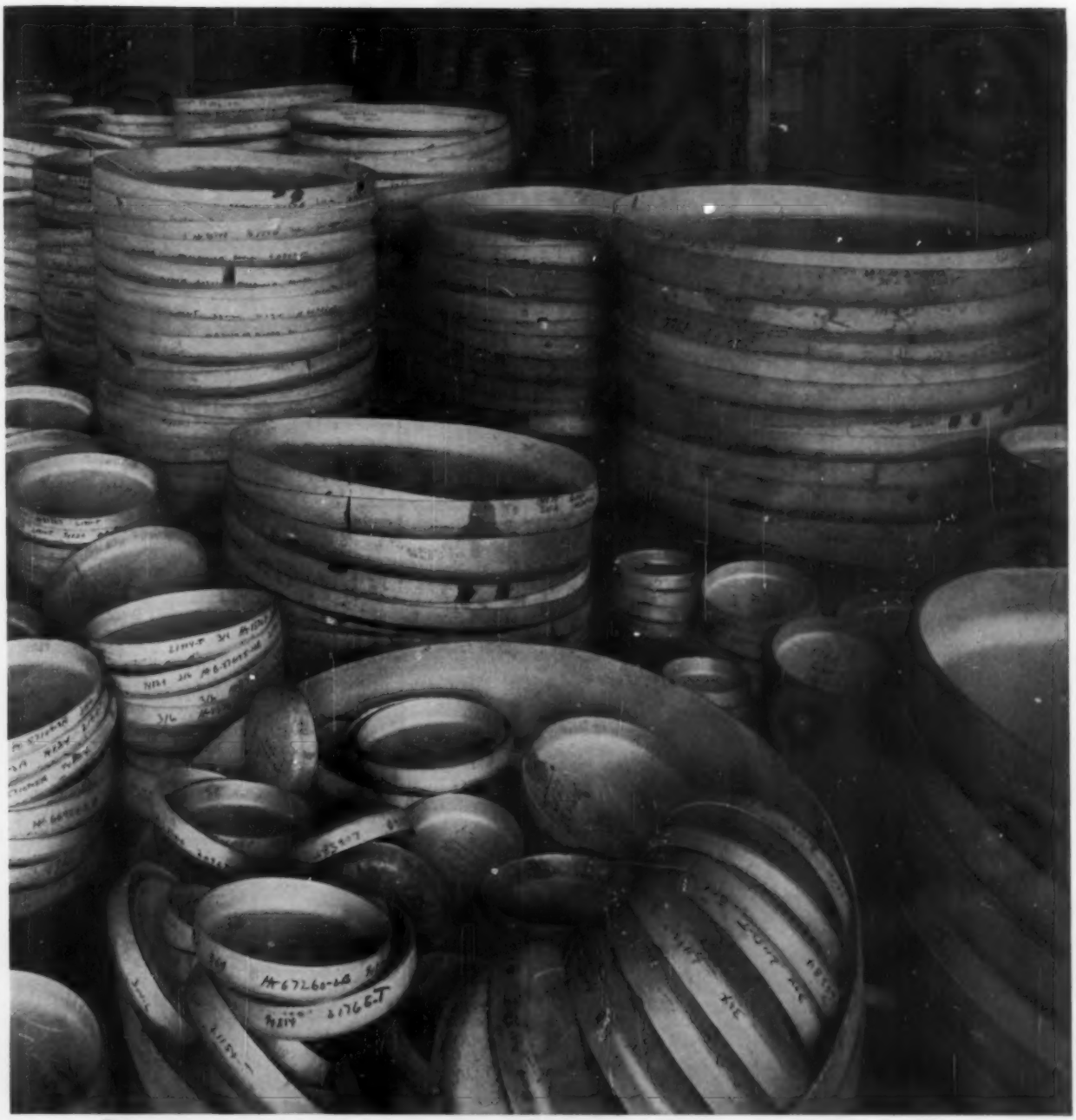

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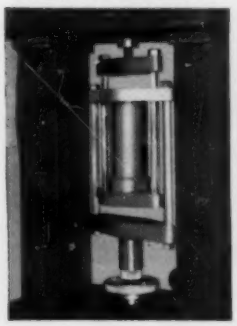

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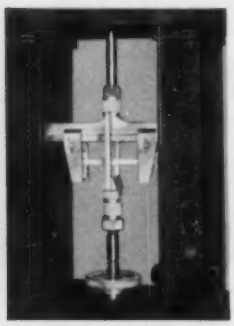

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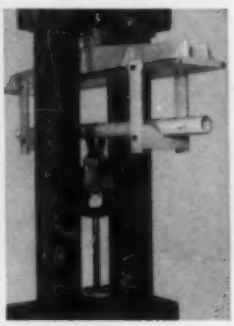

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Corrosion . . .

spring steel, Ni-Hard, Hadfield manganese steel, white cast iron containing chromium, grey cast iron, rail steel, mild steel, and chilled cast iron.

Flat panels, 3½ in. square and ranging from ⅛ to 1/16 in. in thickness, were used. They were hung on a line 10 ft. from the ground and were faced alternately southwest and northeast to equalize the effects of the winds. The length of exposure was determined by a control panel of panel steel which was exposed until it had gained 0.175 g. due to corrosion. This period of time was referred to as a standard corrosion week.

The corrosion products were removed by abrasion on a linishing machine using a fine grit belt. Each panel was pressed against the belt with a pressure of 0.65 psi. Each face was abraded for 20 sec. (10 sec. in each of two directions at right angles to each other). The panels were weighed at the start of the experiment and again after a suitable number of exposures. The loss of weight was the criterion of the resistance of the material to the imposed conditions.

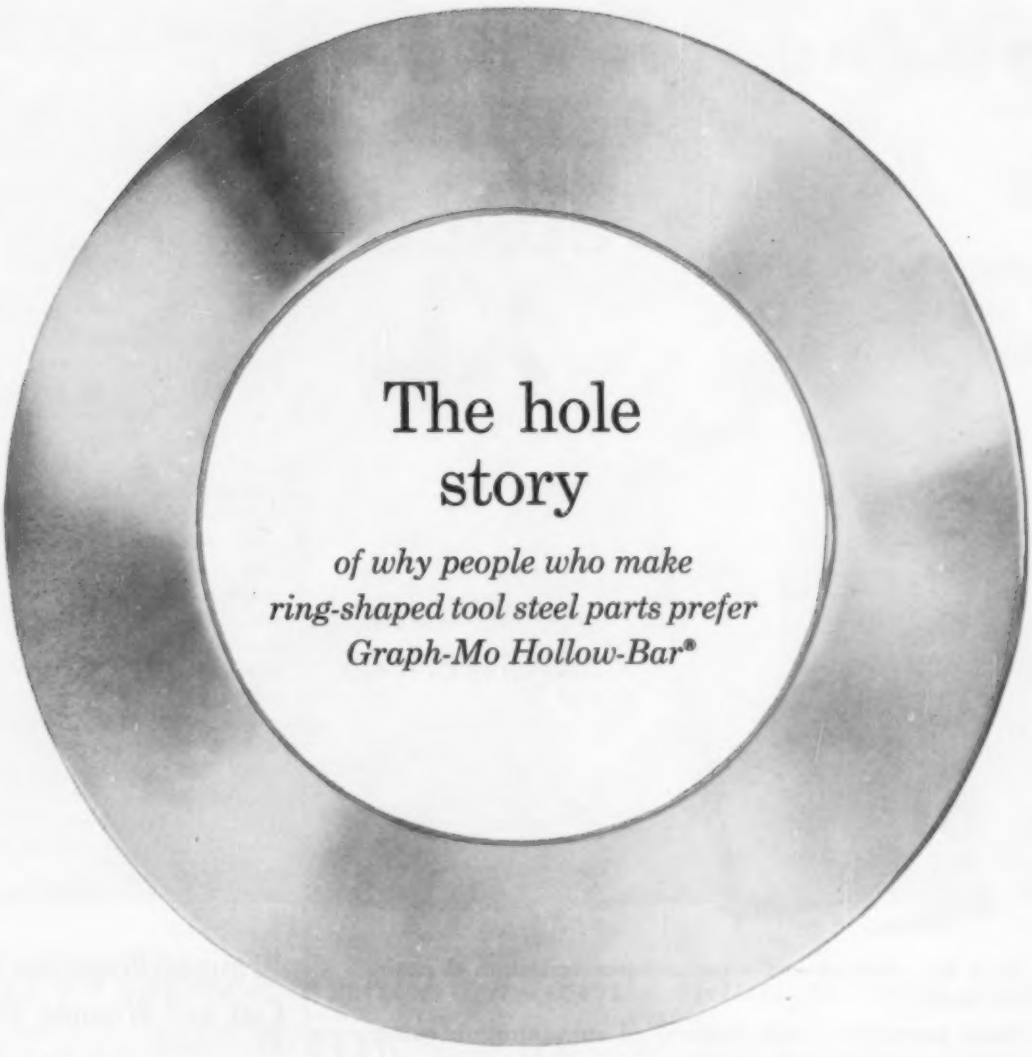
The tests were conducted by exposing single panels of the various metals for periods of ½, 1, 2, 4 and 8 standard corrosion weeks between abrasions, and three panels of each material were exposed continuously for one year with no abrasion on the surface.

The results show that the abrasion resistance of the rolled steels is directly proportional to their carbon equivalent rather than to their hardness, with small increases in carbon equivalent resulting in large decreases in abrasion loss. The carbon equivalent was calculated by the following formula:

$$C.E. = C + Mn/3 + Cr/3$$

With alternate corrosion and abrasion, all the materials showed an increased rate of corrosion with increasing frequency of abrasion.

Ni-Hard, white iron plus chromium, and chill cast iron all showed exceptional resistance to corrosion, to abrasion, and to all combinations of the two. The slow rusting qualities of Cor-Ten were evident only in the absence of abrasion. When



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Corrosion . . .

abrasion took place once or twice per standard week, it corroded like mild steel.

Under the influence of corrosion alone, grey cast iron reacted similarly to the unalloyed steels. However, with increasing frequency of abrasion, its resistance increased and it exhibited abnormal resistance to abrasion with or without slight corrosion. Both normalized and hardened spring steel exhibited the same rate of corrosion, but the hardened variety was slightly superior to combinations of corrosion and abrasion.

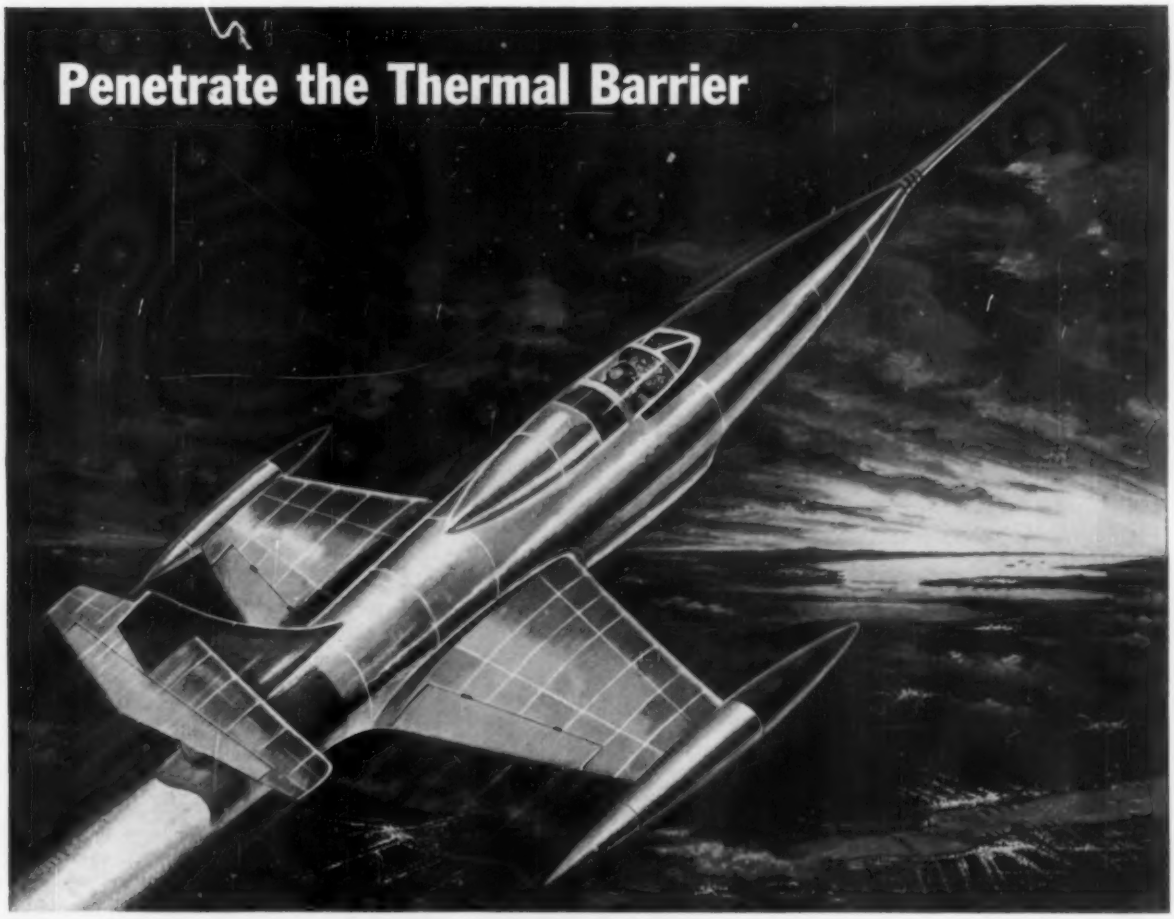
The corrosion rate of rail steel was similar to that of the other carbon steels, but when abraded every week or two it had the lowest resistance to the corrosion-abrasion combination. Hadfield manganese steel was the most resistant to corrosion alone of all steels tested and was the least affected by increasing frequency of abrasion. Under abrasion alone, it was not as satisfactory as grey iron, chilled white iron or white iron plus chromium. Panel steel was similar to mild steel except that, under pure abrasion, it was the worst of the materials tested. Mild steel was not very much better.

BERNARD TROCK

Fatigue Properties of Cast and Wrought Steels

Digest of "Fatigue Properties of Comparable Cast and Wrought Steels", by E. B. Evans, L. J. Ebert, and C. W. Briggs, A.S.T.M. Preprint No. 64, 1956.

THE EFFECTS OF variations in steel composition, heat treatment, surface finish, directionality properties, and section size on the fatigue properties of cast and wrought standard carbon and low-allow steels in the 0.30 to 0.40% carbon range were studied. Fatigue tests, carried out in R. R. Moore rotary-bending machines, were supplemented by tension and hardness tests on all steels. In addition, room-temperature impact tests were made on the cast steels used in the section size study. All steels were heat treated before machining; the plain carbon steels were either annealed or normalized and tempered, and the low-alloy



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Fatigue Properties . . .

steels were either normalized and tempered or quenched and tempered.

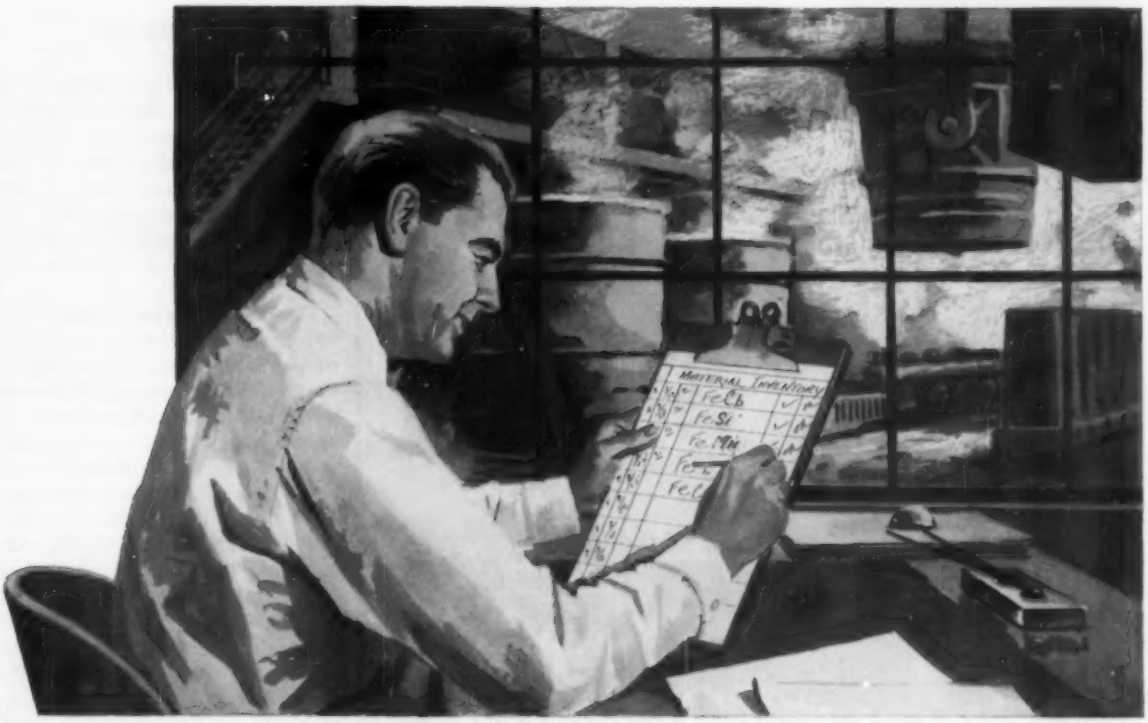
Effect of Composition and Heat Treatment. Five cast steel grades (1040, 1330, 4135, 4335, and 8630) were tested together with five comparable wrought steels of 1040, 1340, 4140, 4340 and 8640 composition. For each steel series having a given heat treatment the tensile strength of the cast and the wrought steel was the same. The steels tested were all in the tensile strength range of 80,000 to 170,000 psi.

The S-N curves for all the unnotched wrought steels showed only a small degree of scatter. The fatigue-test results on the comparable cast steels showed more scatter, but in general the endurance limit for 10 million cycles appeared to be well defined on the S-N curves. There was no sharp knee in the S-N curve for the cast steels, but a sharp discontinuity was evident at about 10^6 cycles on the curves for the wrought steels.

For steels of equal tensile strength, in all cases the endurance limit of the cast steel was about four-fifths of the longitudinal endurance limit of the comparable wrought steel. This relationship appeared to be unaffected by steel composition and type of heat treatment. The endurance ratio for plain carbon steels in both the fully annealed and the normalized and tempered conditions was 0.40 for cast steel and 0.48 for wrought steel. The endurance ratio for the four alloy series steels in both normalized and tempered and in the quenched and tempered conditions fell in the range 0.42 to 0.50 for the cast steels, and for the wrought steels in the range 0.55 to 0.60.

In comparing each steel series for a given heat-treatment the endurance limit of notched cast steel was about the same as that of comparable wrought steel. The endurance ratio range for cast steels was 0.28 to 0.32, and for wrought steels 0.27 to 0.32. Values of the notch sensitivity factor show that the cast steels are less notch sensitive than the comparable wrought steels at all tensile strength levels.

Although the notch dimensions were held constant the authors were able to calculate, from previously



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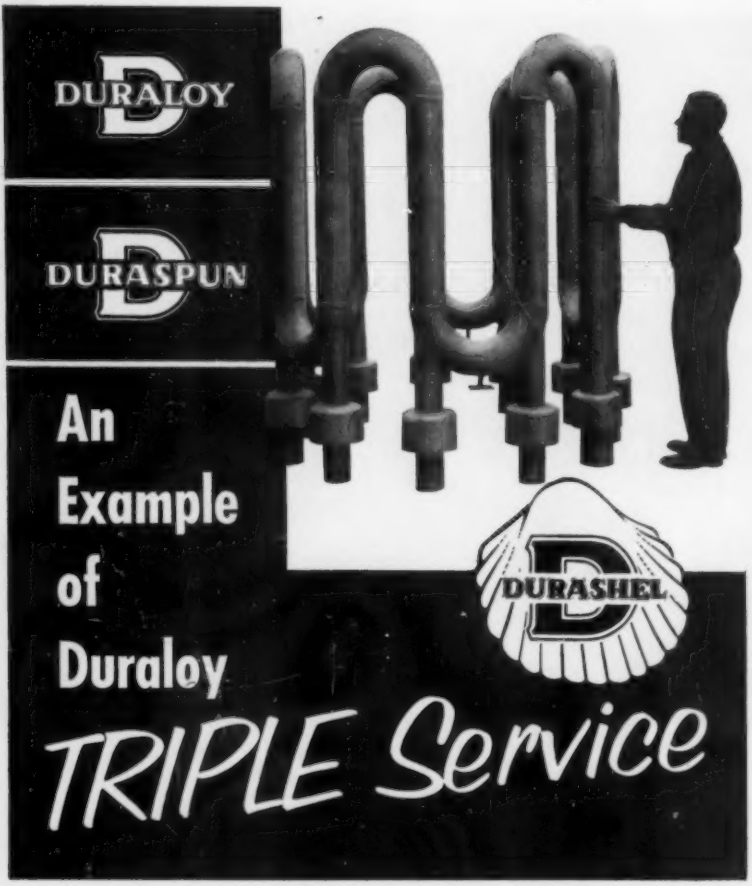

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Fatigue Properties . . .

published curves, the influence of varying notch severity on the endurance limit of the steels. In general, mild external notches did not affect the endurance limit of cast steels as much as wrought steels. At greater notch severities, no distinction could be drawn between the two series of steels.

Effect of Surface Finish. The effects of as-cast, polished, and lathe-turned finish on the fatigue properties of a cast and wrought 8640 steel were studied. Specimens with an as-cast finish were cast to shape with and without risers, to determine any effect due to centerline shrinkage. For a polished finish, the endurance ratio for the cast steel (0.45) was about four fifths of the wrought steel (0.59). With a lathe-turned finish the endurance ratio for the cast steel was unaffected, whereas the ratio for the wrought steel decreased to 0.46. A considerable decrease in fatigue properties occurred in cast-to-shape fatigue specimens having an as-cast finish, the endurance ratio being reduced to 0.32. This ratio was the same for specimens made with and without risers, thus indicating no effect of centerline structure. The effect of the as-cast finish may be partly due to a small degree of surface decarburization and to the inertia stresses resulting from the shape of the cast test bar.

Effect of Directionality. The endurance ratios of wrought 4140 steel in the longitudinal and transverse directions were shown to be 0.55 and 0.48, respectively. Notched specimens gave similar values in both the longitudinal and transverse directions, the values being 0.25 and 0.24 respectively. A comparison with the cast steel revealed that the endurance limit for the unnotched cast steel is lower than the endurance ratio of the wrought steel in the longitudinal direction, but almost the same as the wrought steel in the transverse direction.

Section Size Effect. Unnotched fatigue specimens were taken from various locations in 1¼, 3, and 6-in. square sections of cast (*a*) normalized and tempered 1030 steel, (*b*) normalized and tempered 8635 steel, and (*c*) quenched and tempered 8635 steel.

(*Continued on p.* 156)

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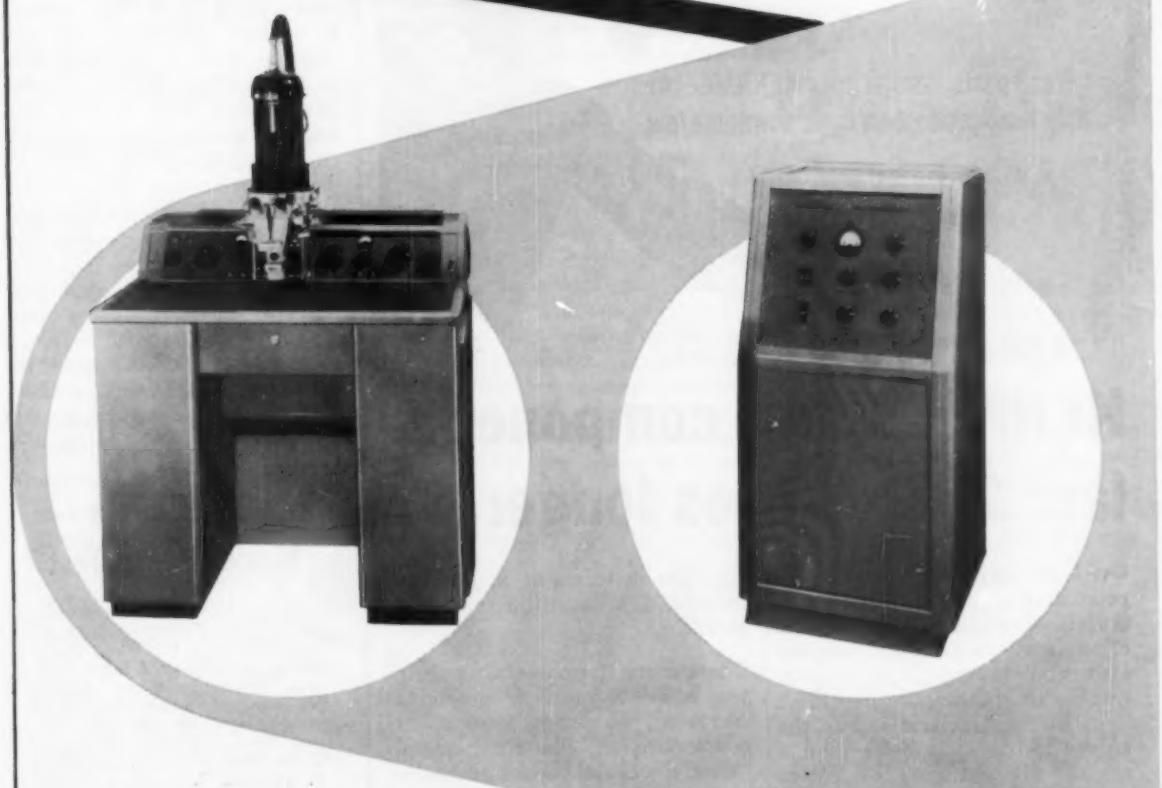
For analysis of opaque specimens



This new apparatus provides a safe, practical means by which critical evaluations of opaque specimens may be made. The PMR X-ray Microscope is an important adjunct to both optical and electron microscopes. Both industry and laboratories dealing with biologicals, pharmaceuticals, agriculture products, minerals, metals, rubber and plastics, as well as forensic problems will find X-ray microscope analyses of inestimable value.

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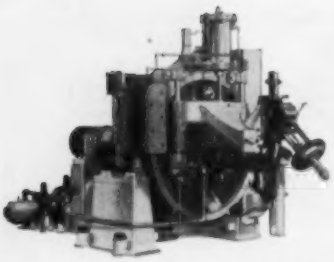

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Fatigue Properties . . .

For a given steel, the endurance limit varied in the same manner as the tensile strength. However, the endurance limit was not solely dependent on the tensile strength. For each of the three steels, the endurance limit was slightly lower at the center of the section. The endurance ratio values for the steels were insensitive to section size increase. In general, the lowest ratio was obtained at the center of the 6-in. section, and the highest at the surface of the 1¼-in. section. The range of minimum-to-maximum endurance ratio was 0.46 to 0.50 for the 1030 steel; 0.34 to 0.42 for the normalized and tempered 8635 steel; and 0.34 to 0.38 for the quenched and tempered 8635 steel.

For a wrought 1030 steel there was little change in the endurance ratio in passing from the surface to the center of a 6¼-in. square hot rolled bloom. Directionality effect, however, in the wrought steels was very marked. W. A. MORGAN

End Quench Hardenability Test

Digest of "Further Development of the End Quench Hardenability Test for Deep Hardening Steels", by Adolph Rose and Leo Rademacher, Report No. 1051 of the Committee on materials of the German Iron and Steel Institute, *Stahl und Eisen*, Vol. 76, Nov. 15, 1956, p. 1570-1573.

THE end quench hardenability test developed by Jominy and Boeghold, and widely used in the steel industry, has one serious limitation: only a relatively narrow range of cooling velocities from the TTT curves can be covered. For velocities falling short of critical, the curve shows little, if any, falling off in hardness since it represents the fully martensitic state over its entire length.

In order to test deep hardening steels, an end quench test for less rapid cooling velocities was developed. Two approaches to the problem were considered: increasing the mass of the Jominy bar toward the upper unquenched end, and heating the unquenched end during the end quench test.

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Since the latter approach is more difficult, tests were limited to the use of a conical cap of corrosion resistant steel, placed over the unquenched end of the standard Jominy bar, thereby increasing its mass. A tight joint assured uniform heating to the austenitizing temperature. The Jominy end quench hardenability bar with cap covered a wider range of cooling velocities than the standard test. The modified test originally was used to determine hardenability values of hot worked steels containing molybdenum, chromium, and vanadium.

Test bars were first ground to a depth of 1 mm., since examination had shown that they are prone to exhibit pronounced decarburization. These steels showed a tendency to transform to an intermediate structure besides martensite and retained austenite. This intermediate structure was more resistant to tempering than martensite. In addition, it led to the phenomena of secondary hardening.

Tests proved beyond a doubt that the cap has the desired effect of widening the range of quenching velocities for a number of austenitizing temperatures. The modified standard Jominy tests can now be used for deep hardening high-alloy steels, also. H. HEINE

Titanium Research

Digest of "Metallurgical Research at TMCA", by H. D. Kessler. Presented at Titanium Conference, Western Metal Congress, March 1957, 30 p.

THE RESPONSIBILITY for research projects at the Titanium Metals Corp. of America is divided among five divisions within the technical department: the process research division, the melting engineering division, the metallurgical research division, the metallurgical standards division, and the development engineering division.

A major problem of the process research division is measurement of the varying oxygen content of titanium sponge from batch to batch. As a process control measure, TMCA checks the hardness of small test ingots, then compares known relationships between oxygen content and Brinell hardness for unalloyed

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Titanium . . .

titanium. Nitrogen, carbon, and hydrogen are more easily controlled and are kept at constant low levels.

The process group are also attempting to develop more accurate and economical methods of oxygen analysis for use in production control. Both the platinum bath technique (vacuum fusion) and the bromination method are used. A comparison of the two indicates that the bromination technique is not as accurate as the vacuum fusion method; the former shows a somewhat larger standard deviation.

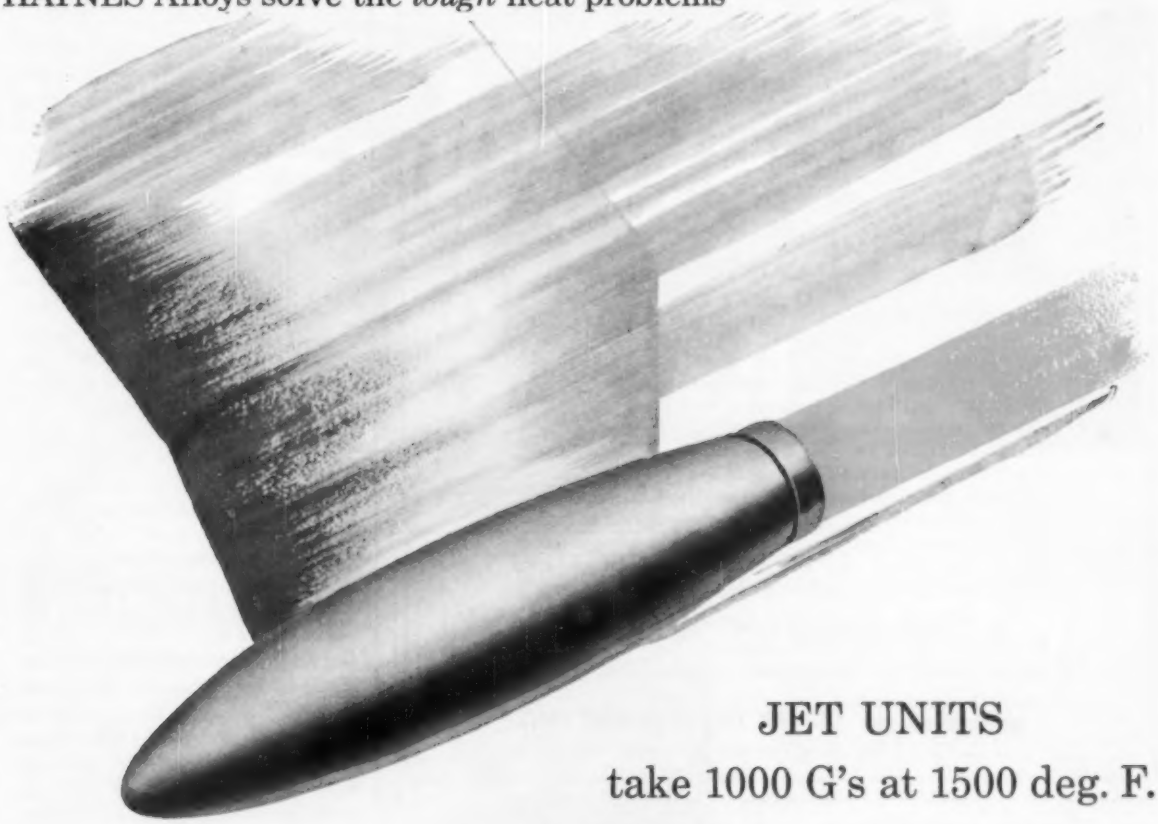
The metallurgical research division has been developing heat treated alloys, particularly 4 Al, 3 Mo, 1 V titanium alloy. This material can be solution-treated to a low-yield condition for ease of formability, and then aged to obtain high strengths. The solution-treating temperature affects the yield strength, which remains low, compared to the tensile strength, for solution temperatures of 1500 to 1650° F. Subsequent aging at 900° F. for 24 hr. increases both the tensile and yield strengths. With a solution temperature of 1650° F., the requirements of the Defense Department (160,000 psi. yield and 180,000 psi. tensile strength) can be met, with good ductility. Even higher strength levels can be obtained in this alloy, at the sacrifice of some ductility and formability. The 4 Al, 3 Mo, 1 V titanium alloy has excellent properties at elevated temperature, with strengths comparable to 6 Al, 4 V titanium alloy up to 800° F.

Heat treatment studies on the alloy 6 Al, 4 V show that it is very quench sensitive during solution treatment. To achieve full properties, the quench must be completed within two seconds.

TMCA has developed a method for solution treating titanium sheet. The material is held by jaws in a horizontal position, under tension, resistance heated, and then spray quenched from both sides. Under ideal conditions, flatnesses of 1 to 2% are obtained. The equipment is being scaled up for heat treatment of 120-in. sheet, and will be used in production.

The formability laboratory investigates such variables as the effect of

HAYNES Alloys solve the *tough* heat problems



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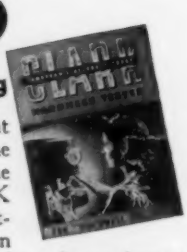
About Hardness Testing



Everything you need to know about hardness testing is told in this handsome book, prepared by the makers of the internationally respected CLARK Hardness Testers for "Rockwell Testing." Simple, easy-to-read text (in English) and numerous illustrations show the equipment and procedure for fast, accurate hardness testing of ferrous and non-ferrous materials. If you would like a copy, *free of charge*, just attach this ad to your letterhead or write "Send book." A copy will be mailed to you promptly.

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Titanium . . .

temperature on forming and on subsequent aged properties, the effect of deformation on final properties, and the amount of distortion or growth during aging after forming. In comparing two titanium alloys, Ti, 4 Al, 3 Mo, 1 V shows a slight increase in aged strength after 10% deformation in the solution-treated condition, with no loss in ductility, while Ti, 2 Al, 6 Mo, 2 V suffers a marked loss in aged strength under the same processing.

The alloy Ti, 6 Al, 4 V possesses excellent creep resistance up to 750° F.; heat treatment improves resistance to creep in this material.

Studies are being made in a WADC sponsored program of Ti-140 A, Ti-155 A, and Ti, 6 Al, 4 V to determine the effects of aging time and temperature on stress-stability, and notch sensitivity and elevated-temperature properties. Curves of room-temperature notch strength as a function of tensile strength (similar to those published for heat treated steels) have been established, as have short elevated-temperature strengths to 800° F. Some early results (Mr. Kessler emphasizes that the data are preliminary) indicate that the alloys are stable after long time exposure to temperatures of 750° F., when given short-time aging treatments at temperatures as low as 900° F.

Ti-140 A sheet shows excellent potential for forming in fully aged conditions, with bends of 3.5 T obtainable in material at the 180,000 psi. tensile strength level. In addition, it is possible that this alloy may be amenable to air cooling from the solution-treating temperature, with attendant improvements in flatness over water quenched sheets.

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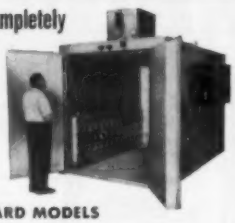

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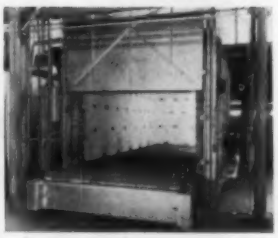

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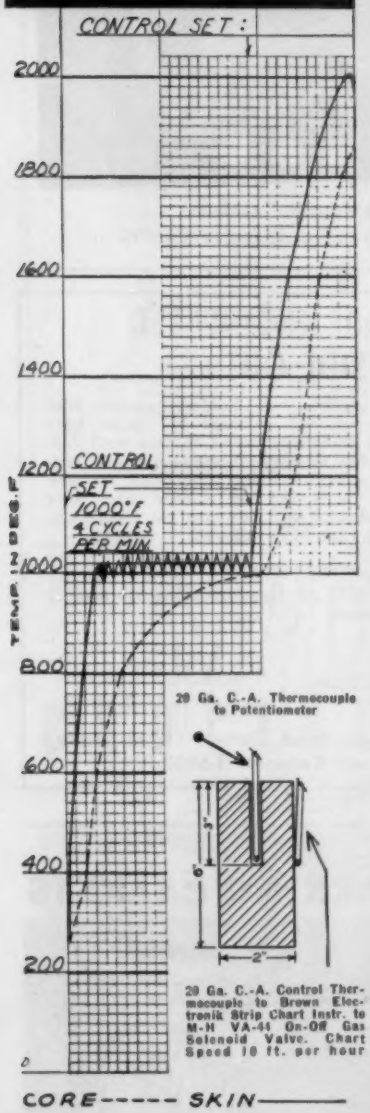

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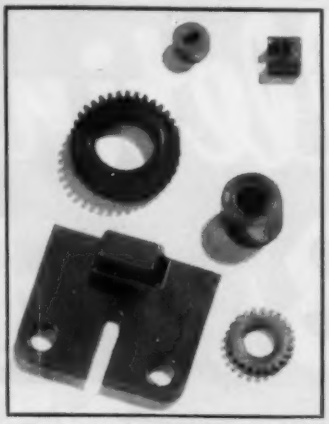

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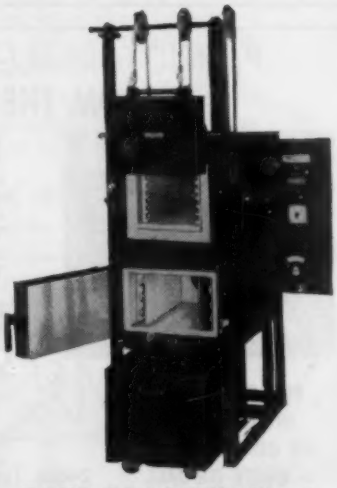

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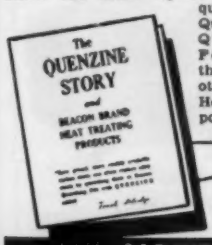

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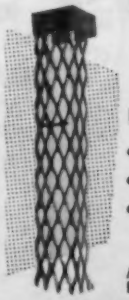

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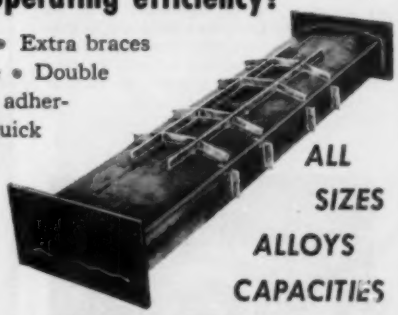

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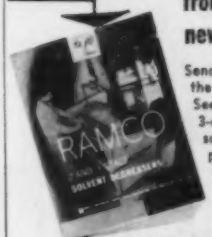

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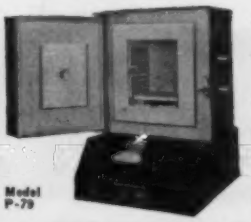
PRODUCED AND PRICED RIGHT FOR YOUR ELECTRIC FURNACE NEEDS

DYNA-TROL

MODEL NO.	FIRING CHAMBER (H.W.D.)	PRICE (300° to 2000°)	PRICE (400° to 2300°)
P48	4½"x4½"x8"	$90.00	$110.00
P79	6"x6"x9"	$205.00	$225.00
P918	9"x9"x18"	$480.00	$528.00
P414	14"x14"x14"	$525.00	$603.25
P124	12"x12"x24"	$715.00	$822.25
P818	18"x18"x18"	$775.00	$887.50
P136	18"x18"x36"	$1125.00	$1312.50

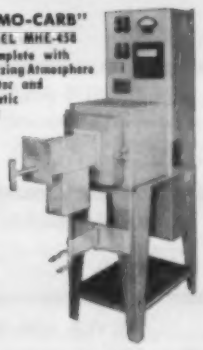
Automatic Controls Available on all Models



Model P-79

- Infinite zone temperature control
- Zone temperature indication by Pyrometer Selector Switch
- Automatic hold and cut-off instrument available
- Patented element holders
- Infinite variety of time-temperature curves obtainable
- Rugged construction

"ATMO-CARB"
MODEL MHE-458
Complete with Carburizing Atmosphere Generator and Automatic Control



$1325.00
Other Sizes and Arrangements Available

L&L MANUFACTURING CO.
Chester 77, Pa.

LIST NO. 138 ON INFO-COUPON PAGE 170

WANTED

SURPLUS FURNACES

REWARD

WE PAY CASH FOR SURPLUS INDUSTRIAL FURNACES AND RELATED APPARATUS

SURPLUS FURNACES FOR SALE

BOX TYPE				**BOX TYPE RECIRCULATING**			
24x36x18	Lindberg	50KW	2000°F	7'x7'x5'	Richards	84KW	450°F
36x72x23	G.E.	72KW	2000°F	6'x12'x42"	Lindberg	Gas	1250°F
48x84x24	American	100KW	1850°F	4'x15'x6'	Despatch	Gas	850°F
24x36x14	Surface	Gas	1850°F	24"x36"x24"	Lindberg	45KW	1400°F
54x96x24	Surface	Gas	1850°F	66"x16'x76"	Lindberg	180KW	1250°F
PIT TYPE				**PIT TYPE CARBURIZERS**			
20x22	G.E.	48KW	1200°F	14x18	L&N Vapo	11KW	1850°F
28x28	Lindberg	52KW	1250°F	14x18	L&N Homo	30KW	1850°F
48x72	Lindberg	Gas	1250°F	20x36	L&N Homo	72KW	1850°F
48x96	Surface	Gas	1250°F	10x20	HeviDuty	14KW	1500°F
48x96	Lee Wilson	Rad. Tube	1850°F	25x48 (New)	L&N Micro	100KW	1850°F
CONVEYOR TYPE RECIRCULATING				**BRAZING TYPE**			
72x40'x30	Surface	RlrHrth Gas	1250°F	18x42x12	Lindberg Pshr	60KW	2500°F
27x15'x12	R&S	MshBlt Gas	1250°F	28x17'x12	G.E. RlrHrth	320KW	2050°F
36x33'x12	Despatch	MshBlt Gas	875°F	62x18'x24	G.E. RlrHrth	655KW	1650°F

SEND FOR COMPLETE LIST

THE JOE MARTIN CO., INC.
19256 John R. St. TWinbrook 2-5500 Detroit 3, Mich.

LIST NO. 160 ON INFO-COUPON PAGE 170

Sel-Rex®

PRECIOUS METALS FOR INDUSTRIAL PLATING

BRIGHT GOLD

Mirror-bright finish in any thickness directly from the bath. Patented

PUR-A-SALTS

Restores contaminated cyanide plating baths to full, trouble-free operation. Patented

SILVREX BRIGHT SILVER

Crystal-clear solution that produces mirror-bright deposits. Patented

SILVER SOL-U-SALT

Non-dusting—safest and easiest to use.

BRIGHT RHODIUM

Brilliant, fine-grained non-tarnishing deposits.

RHODEX

Only rhodium electroplating process that yields extra heavy compressively stressed deposits. Patent Pending

ACID GOLD PLATING PROCESS

Developed specifically for plating printed circuits. Mildly acid so that neither the laminate nor the adhesive at the inter-face of printed circuit boards are affected during the plating process.

Complete installation and servicing on all precious metals processes.

SEL-REX CORPORATION

Dept. BB, Nutley 10, New Jersey

Offices: Detroit, Chicago, Los Angeles

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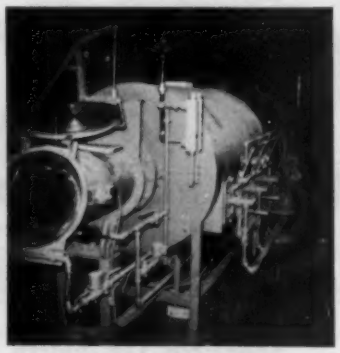
GOOD USED EQUIPMENT AT REAL SAVINGS TO YOU!

In our large, rapidly turning-over stock, we often acquire brand-new items, still in their original crates. We offer these at a fraction of their replacement cost, and with the same guarantee that the original manufacturer gives. One of our new furnaces is pictured below.



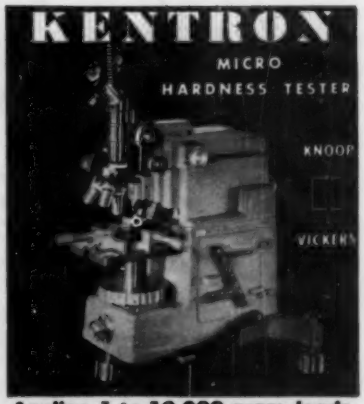
Lindberg "Iron Lung" Pusher

Our stock is constantly changing! Before you buy any furnace or accessory, call us collect and let us show you how to save money! (Money-Back Guarantee). We pledge that any unit we advertise is in stock at one of our warehouses at the original time of publication. However, they are subject to prior sale, so act now!

METAL TREATING EQUIPMENT EXCHANGE, INC.
9825 GREELEY ROAD
DETROIT 11, MICHIGAN

LIST NO. 142 ON INFO-COUPON PAGE 170

KENTRON
MICRO HARDNESS TESTER



Applies 1 to 10,000 gram loads

Write for Bulletin

Kent Cliff Laboratories Div.
The Torsion Balance Company
CLIFTON NEW JERSEY

LIST NO. 53 ON INFO-COUPON PAGE 170

Controlled Atmospheres

Including chemical equilibrium, prevention of oxidation, type of reaction, surface effects; extensive discussions covering costs. 17 eminent authorities participate in this important volume. 323 pages — 6x9 — red cloth — $4.00. Clip and send to ASM Information Service, 7301 Euclid Ave., Cleveland 3, Ohio.

JELLIFF

HEAT-TREATING BASKETS
All shapes, sizes, alloys.
Estimates without obligation.

THE C. O.
JELLIFF
MANUFACTURING CORP.
SOUTHPORT, CONNECTICUT

LIST NO. 91 ON INFO-COUPON PAGE 170

make hardness tests
ANYWHERE
WITH THE
NEWAGE
TESTER

- CLAMPS, JAWS & BASE PLATE ARE ELIMINATED
- NO CONVERSIONS OR CALCULATIONS
- TEST ANY SIZE, SHAPE OR TYPE METAL
- NO SKILL REQUIRED
- SCALE READINGS IN ROCKWELL & BRINELL
- ACCURACY GUARANTEED

Many thousands used by industry and government. Write, wire or call for additional details and prices.

NEWAGE INDUSTRIES, INC.

222 York Road *Jenkintown, Pennsylvania*
TUrner 6-8494 *Dept. MP*

LIST NO. 163 ON INFO-COUPON PAGE 170

STEEL FABRICATED and RUBBER-LINED TANKS for the Plating Industry

ARco

- Plating tanks any size or shape fabricated and rubber-lined to your specifications. A complete service from basic design to installation, also fabricated and rubber-lined pipe and fittings. Write Dept. "MP" for complete details.

Subsid. of Automotive Rubber Co., Inc.

ARco STEEL FABRICATORS • INC.
12542 BEECH ROAD • DETROIT 39, MICH.

LIST NO. 153 ON INFO-COUPON PAGE 170

Photomicrograph shows diffusion structure of the CHROMALLOY Case. At the surface the chromium content is 35% to 45%.

CHROMIZING PROCESS COMBATS... HEAT WEAR CORROSION

CHROMALLIZING diffuses chromium into the surface of iron and steel parts, providing the corrosion resistance of stainless steel and the wear resistance of chromium carbides. CHROMALLOY Case cannot chip, peel or flake.

Chromalloy Corporation is fully equipped for processing large or small quantities of parts. Engineering advisory service available.

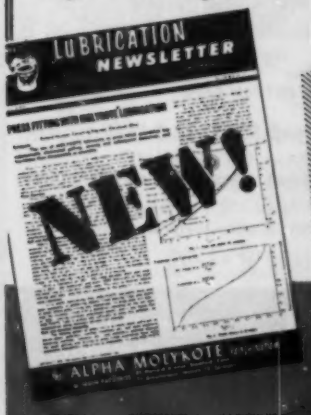
FREE! TECHNICAL BULLETINS

Chromalloy CORPORATION

451 Tarrytown Road, White Plains, N.Y.
Telephone White Plains 6-0020

LIST NO. 146 ON INFO-COUPON PAGE 170

Engineering Data on MOLYKOTE® lubricants



- Being published regularly
- Every issue features a full-length technical article on the use of MOLYKOTE Lubricants in industry.
- "How-to" stories on tough lubrication applications
- Get on our mailing list TODAY. Write to

The ALPHA MOLYKOTE CORPORATION
Main Factories:
65 Harvard Avenue, Stamford, Conn.
71 Amalienstrasse, Munich 19, Germany

LIST NO. 110 ON INFO-COUPON PAGE 170

Technic Gold is in orbit with "Explorer"

Certain component parts of "Explorer", the first American satellite, required gold plating. Logical choice was Technic 24 karat INDUSTRIAL GOLD — the first and purest soluble 24 karat gold in the world. Or out of it!

UNIQUE PROPERTIES SOLVE UNIQUE PROBLEMS

Precious metals are finding extraordinary applications in industry and the laboratory. Electroplating offers an efficient method of exploring and exploiting such characteristics as the unique and diverse properties of gold — not found in combination in any other form.

TECHNIC SERVICE

If you have requirements for electroplated gold, other precious metals, or alloys — consult Technic. We equip you with controlled electroplating apparatus and/or solutions that eliminate variables, assure precise performance reproducible as often as required. Find out how Technic Service assures quality with economy.

Phone, wire, TWX or write . . .

160-8

TECHNIC, INC.

39 Snow Street,
Providence, R. I.
JAckson 1-4200
Chicago Office—7001
North Clark Street

THE LARGEST ENTERPRISE OF ITS KIND IN THE WORLD

LIST NO. 124 ON INFO-COUPON PAGE 170

Solve
Inspection
Sorting
Demagnetizing
Problems

with
MAGNETIC ANALYSIS...

MULTI-METHOD EQUIPMENT

Electronic equipment for non-destructive production inspection of steel bars, wire rod, and tubing. Detects mechanical faults and variations in composition and physical properties. Average inspection speed – 120 ft. per minute.

SPECIAL EQUIPMENT

Electronic equipment for non-destructive production inspection of non-ferrous bars and tubing . . . as well as both non-magnetic stainless and high temperature steel bars and tubing – seamless or welded. Mechanical faults, variations in composition and physical properties are detected simultaneously. Average inspection speed – 200 ft. per minute.

WIRE ROPE EQUIPMENT

Electronic equipment for inspecting ferromagnetic wire ropes from 1/32" to 3" diameter. Detects broken, cross-over or missing wires, plus defective welds and deformations at production speeds up to several hundred feet per minute.

COMPARATORS AND METAL TESTERS

Electronic instruments for production sorting of both ferrous and non-ferrous materials and parts for variation in composition, structure and thickness of sheet and plating.

DEMAGNETIZERS

Electrical equipment for rapid and efficient demagnetizing of steel bars and tubing. When used with Magnetic Analysis Multi-Method Equipment, inspection and demagnetizing can be done in a single operation.

MAGNETISM DETECTORS

Inexpensive pocket meters for indicating residual magnetism in ferrous materials and parts.

"THE TEST TELLS"

For Details Write:

MAGNETIC ANALYSIS CORP.
42-44 Twelfth St., Long Island City 1, N. Y.

LIST NO. 51 ON INFO-COUPON PAGE 170

Pickling Tank Test in 3 minutes . . .

WITH FERRO PICKLE PILLS!

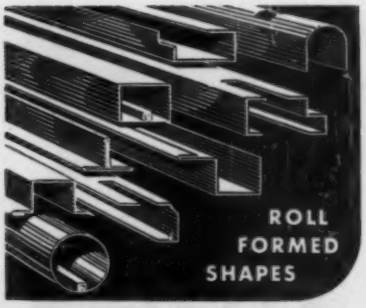
Any workman who can tell red from green and count to ten can test the exact strength of pickling solutions . . . *the exact percentage of iron content*, and the solution percentage of sulphuric acid, muriatic acid, alkali etc. in metal cleaning tanks.

Ferro Pickle Pills provide a quick, accurate test to augment periodic titration testing, or as a "test within a test". They can assure full-capacity cleaning with fewer rejects, save money by eliminating premature dumping of tanks. That's why more and more companies are using them. Why don't *you* try them? Write today for literature and prices,

FERRO

FERRO CORPORATION
4133 East 56th Street
Cleveland 5, Ohio

LIST NO. 175 ON INFO-COUPON PAGE 170



Reduce your assembly problems and costs. Our shapes continuously formed, with high degree of accuracy, from ferrous or non-ferrous metals. Write for Catalog No. 1053.

ROLL FORMED PRODUCTS CO.

MAIN OFFICE AND PLANT
3761 OAKWOOD AVE. • YOUNGSTOWN, OHIO
LIST NO. 101 ON INFO-COUPON PAGE 170

Need Help Designing That Aluminum Extrusion?

TEAM UP with JARL

THERE'S A WORLD OF DIFFERENCE

The *difference* starts the moment you meet the Jarl salesman. He's an engineer . . . well qualified to make on-the-spot recommendations in designs. Team up with Jarl and you'll get the right shapes made to most exacting design specifications. You'll be sure of close die control . . . quality safeguards every step . . . on-time deliveries. Send for our stock die catalog or send rough sketches for assistance with your design.

ANODIZING

JARL EXTRUSIONS, INC.
Dept. MP, Linden Ave. • East Rochester, N. Y.
LIST NO. 165 ON INFO-COUPON PAGE 170

ULTRASONIC

Thickness Testing from One Side

Rapid, Accurate, Non-Destructive

VIDIGAGE®

14" or 21" Cathode-Ray Screen with direct-reading scales between 0.005" and 2.5"; accuracy 0.1% to 1.0%.

AUDIGAGE®

Portable Thickness Testers for ranges from 0.020" to 4" or 0.060" to 12" of steel; accuracy up to 1.0%.

Detect Laminar Flaws and Lack of Bond

BRANSON INSTRUMENTS, INC.
6 Brown House Rd., Stamford, Connecticut

Specializing in Ultrasonics Since 1946

LIST NO. 81 ON INFO-COUPON PAGE 170

GET A BID FROM

HOOVER

SPECIALISTS IN THE FIELD OF

Die Castings

SINCE 1922

Aluminum and Zinc

THE HOOVER COMPANY
Die Castings Division
North Canton, Ohio
In Canada—Hamilton, Ontario

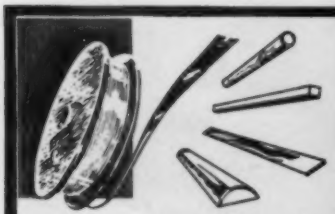
LIST NO. 74 ON INFO-COUPON PAGE 170

END POT FAILURE

Switch to *scheduled* pot maintenance with low-cost pressed-steel pots for lead, salt, cyanide, oil-tempering, metal-melting. Can't turn suddenly defective, because no faulty steel survives drawing. Request catalog from Eclipse Fuel Engineering Co., 1127 Buchanan St., Rockford, Ill.

Eclipse INDUSTRIAL COMBUSTION DIVISION

LIST NO. 176 ON INFO-COUPON PAGE 170



ROUND, SQUARE, FLAT AND HALF-ROUND WIRE FOR MASS PRODUCTION OF SMALL PARTS

Beryllium Copper • Bronzes
Other Non-ferrous Alloys
Rounded or square edges.
Available with hot-tinned finish for solderability.
Write for descriptive folder.

LFA LITTLE FALLS ALLOYS INCORPORATED
193 Caldwell Ave., Paterson 1, N. J.

LIST NO. 66 ON INFO-COUPON PAGE 170

Whitelight MAGNESIUM

your comprehensive independent mill source of magnesium alloy . . .

ALLOYS
AZ10
AZ31
AZ51
AZ61
AZ81
ZK60
ZK30
M-1
HK31
HM21

RODS ½" dia. to 6½" dia.
BARS, STRIPS .022" min. to 7½" max.
SOLID SHAPES .022" min. to 6½" circle
TUBING ¼" O.D. to 8" O.D.
HOLLOW SHAPES ¼" to 6½" circle
PLATE & SHEET .002" to 3" thick

WHITELIGHT MAGNESIUM

WHITE METAL ROLLING & STAMPING CORP.
82 Moultrie Street Brooklyn 22, N.Y.
Factories: Brooklyn, N.Y. • Warsaw, Ind.

LIST NO. 67 ON INFO-COUPON PAGE 170

How Roll Coater

Pre-Painted

METAL SAVED MONEY AND IMPROVED QUALITY ON

R-C-000 LICENSE PLATES

PROBLEM:

Stello Products Company, Logansport, Indiana, manufacturer of tags, license and "booster" plates, had the problem of excessive direct labor charges. In the previous expensive method of making these items, plates had to be stamped from bare metal —and then cleaned individually—and spray painted on both sides. This method did not give the uniform quality demanded—and Stello turned to Roll Coater for a solution.

SOLUTION:

Roll-coated metal was tested by Stello Products Company. *Pre-painted* and *baked* on both sides, this metal eliminated *entirely* the cleaning and spray painting operations—withstood rigorous stamping tests—and relieved painting facilities for other jobs. Says J. C. Cotner, president of Stello Products Company, "Roll Coater metal is now saving us approximately 50% in direct labor costs—and is giving us the desired uniform quality in our plate production. It really solves our problem."

SEND FOR FREE BROCHURE and SAMPLE TODAY!

Roll Coater INCORPORATED
PENDLETON, INDIANA

LIST NO. 155 ON INFO-COUPON PAGE 170

THE NEW

DERMITRON

NON-DESTRUCTIVE COATING THICKNESS TESTER

FAST... ACCURATE NON-DESTRUCTIVE DIRECT-READING

- Instantly measures the thickness of metallic and non-metallic coatings and films
- Based on eddy-current principles
- Enables measurements on small or otherwise inaccessible areas

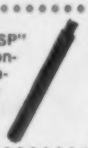
This portable instrument for both laboratory and production use, gives fast, accurate and direct readings of virtually any coating on any base, including:

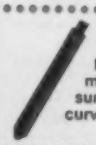
- Metal coatings (such as plating) on metal base (magnetic and non-magnetic)
- Non-metallic coatings (such as paint, anodizing, hard-coat, ceramic) on metal base
- Metal films (such as vacuum metalizing) on non-metallic base (plastics, ceramics)

MEASURING PROBES ARE AVAILABLE IN THE THREE TYPES SHOWN BELOW

NEW RIGHT-ANGLE PROBE model "RP" enables measurements in holes down to ½" I.D.

STANDARD PROBE model "SP" enables measurements on convex surfaces down to ⅛" radius of curvature and on concave surfaces down to 2" radius of curvature





MODIFIED STANDARD PROBE model "MP" enables measurements on concave surfaces down to ¼" radius of curvature

Each of the above probe types is available in 4 different thickness ranges—A, B, C and D, from thick to thin deposits.

Write for latest bulletins and questionnaire to help solve your thickness testing problems

UNIT PROCESS ASSEMBLIES, INC. UPA

LIST NO. 139 ON INFO-COUPON PAGE 170

the GENUINE BRINELL

HARDNESS TESTING MACHINES made by the Alpha Co. of Sweden and available from our stock at New Rochelle

Never approached in ACCURACY AND CONSTANCY of calibration . . . at the standard 3000kg test load . . . maximum error plus or minus 2½ kg

Write for Bulletin No. A-18

GRIES INDUSTRIES, INC.
Testing Machines Division
NEW ROCHELLE 3, N.Y.

LIST NO. 135 ON INFO-COUPON PAGE 170

WRITE FOR GRAPHITE INFORMATION

✓ **CUSTOM MACHINED PARTS FOR SEMICONDUCTOR PROCESSING**
Your custom requirements are available . . . matchlessly machined . . . high purity graphite for all phases of semiconductor processing: reduction and refining boats—crystal-pulling heaters and devices—fusion jigs and components.

✓ **PRODUCTS FOR SPECIAL METALLURGICAL APPLICATIONS**
Complete range of stock sizes in rods, blocks and tubing available. Also, your custom requirements of specially machined articles can be promptly produced.

✓ **PREFORMED SHAPES FOR VACUUM FUSION ANALYSIS**
Matched crucible and funnel combinations . . . powder and chips . . . all available from stock for immediate shipment.

✓ **SPECTROGRAPHIC ELECTRODES**
Recognized as the standard of the world, United's rods, powders and wide range of preformed electrodes are available in the right sizes and designs for your spectrographic work.

Write today To
UNITED CARBON PRODUCTS CO.
P. O. Box 269 • Bay City, Mich.

LIST NO. 179 ON INFO-COUPON PAGE 170

STAR STAINLESS SCREW CO.
CORROSION RESISTANT
647 Union Blvd., Paterson 2, N. J.
Telephone: CLifford 6-2300
Direct N.Y. 'phone Wiscomsin 7-9041
Direct Phila. 'phone WAlnut 5-3660

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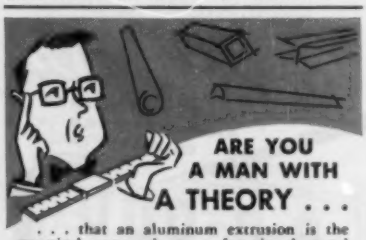
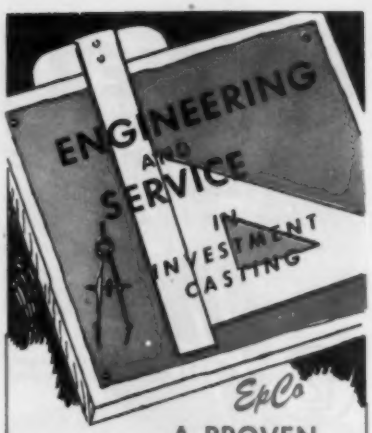


ARE YOU A MAN WITH A THEORY . . .

. . . that an aluminum extrusion is the practical approach to a functional metal parts application . . . at a savings in time and money, and without loss in quality? In fact, the properties — you theorized — of extruded aluminum would even be better? If so, G.E.I.'s engineers are ready to consult with you — without obligation, on one part or a million — to determine how practical your idea is. G.E.I. engineers specialize in adapting extruded aluminum to *new* functional roles.

GENERAL EXTRUSIONS, INC.
[illegible] LAKE PARK RD., YOUNGSTOWN, OHIO. Sterling 3-9[illegible]
Missouri, S. Illinois Representative: Frank May Co., 4378 Lindell Blvd., St. Louis 8, Mo.
Michigan Representative: Howard B. Jones, 15842 Kentfield Ave., Detroit 23, Mich.
Southern Distributor: General Extrusions of Memphis, Inc., 4482 Summer Ave., Memphis, Tenn.

LIST NO. 141 ON INFO-COUPON PAGE 170



A PROVEN DEPENDABLE SOURCE

FOR BETTER GRADE INVESTMENT CASTINGS IN FERROUS AND NON-FERROUS METALS

INVAR CASTING Special Feature — Nickel content held to 35% minimum — 36% maximum

STAINLESS STEEL PART for milk bottling unit formerly machined from solid stock. Only finish operations required are reaming small dia. of counterbored hole and drilling and tapping for set screw.

ENGINEERED PRECISION CASTING CO.
MORGANVILLE, N. J.

LIST NO. 4 ON INFO-COUPON PAGE 170

MARKING DIES

Matthews also feature a complete line of General and Special Purpose Machines. Send for Bulletin GPF-200.

Integrate your marking operations by utilizing present equipment and incorporating a Matthews' Marking Device! **Matthews will machine and engrave a die or type to suit your product. Our complete line of Type and Die Holders, too, are easily designed to fit existing press equipment. Write or call today for additional information.**

JAS. H. MATTHEWS & CO.
Over 100 Years of Service to Industry
3968 Forbes St. Pittsburgh 13, Pa.

LIST NO. 166 ON INFO-COUPON PAGE 170

HAWKRIDGE METALS CORPORATION

Producers and Sellers of

TITANIUM POWDER

−40 to +300 mesh

High Purity	99.2% Pi
Commercial	98.6% Pi

North Hampton
New Hampshire

LIST NO. 177 ON INFO-COUPON PAGE 170

HARDNESS TESTING
SHORE SCLEROSCOPE

Pioneer American Standard Since 1907

Available in Model C-2 (illustrated), or Model D dial indicating with equivalent Brinell & Rockwell C Hardness Numbers. May be used freehand or mounted on bench clamp.

OVER 40,000 IN USE

SHORE INSTRUMENT & MFG. CO., INC.
90-35M Van Wyck Exp., Jamaica 35, N.Y.

LIST NO. 133 ON INFO-COUPON PAGE 170

AIRco AIR WASH SYSTEMS

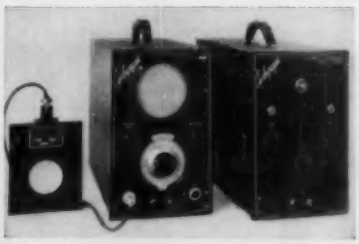
PLATING • PICKLING • METAL CLEANING *FUME SCRUBBING*

• Reasonable initial cost . . . economical in operation . . . no moving parts . . . efficient in performance . . . compact—requires little space . . . standard units—7200 to 57600 C.F.M. Write Dept. "MP" for complete information.

AUTOMOTIVE RUBBER CO. • INC.
12550 BEECH ROAD • DETROIT 39 MICH.

LIST NO. 154 ON INFO-COUPON PAGE 170

DICE
does it better!



THE CYCLOGRAPH, (Model C)

. . . for unscrambling metal mixups

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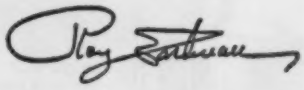

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Titanium Rivets

Digest of "Titanium Rivets—Solid and Blind", by H. S. Brenner. Presented at Titanium Conference, Western Metal Congress, March 1957, 20 p.

THE USE of titanium fasteners, such as rivets, screws, nuts and bolts, instead of steel fasteners of equal size, is said to give a saving of about 40% in weight, with equal strength, no magnetism, and excellent corrosion resistance. Titanium alloy bolts and screws, found reliable for use in aircraft, are now specified for such applications, but the development and assessment of titanium rivets has gone unnoticed in the emphasis to perfect bolts and screws. In studying the problem of rivets for aircraft structures where temperatures as high as 600° F. might be encountered, titanium alloys, provided they are cold headed, seem to offer the best competition to Monel metal. For use with thin high-strength sheets, it is the author's opinion that rivets exhibit their best strength properties and would be preferred to threaded fasteners.

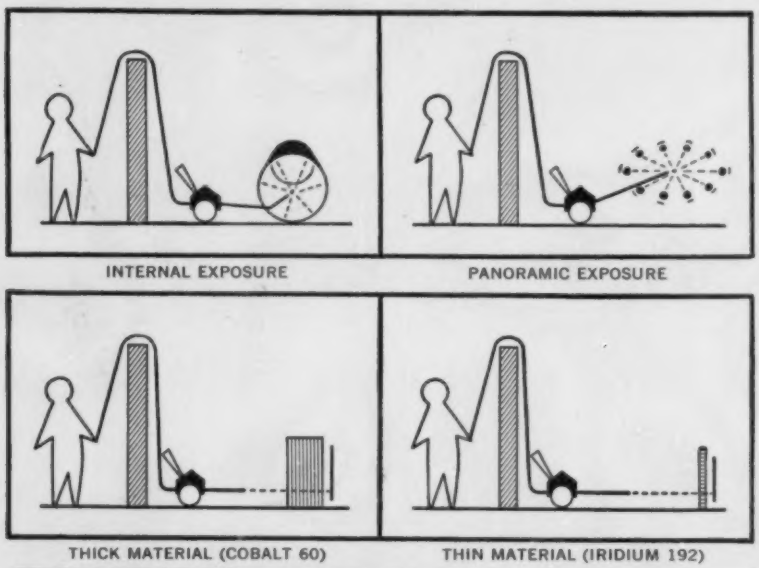
The first attempts to cold head titanium wire of 55,000 and 70,000 psi. yield strength and to use it as rivets were unsuccessful because the wire was deficient in uniformity and ductility. Later some Japanese wire was obtained that could be cold headed and cold upset quite well but this source dropped out of the picture, and finally domestic wire was made that could generally be used for rivets when annealed and properly lubricated.

Although commercially pure titanium rivets cracked when upset with a pneumatic-type riveting hammer in the "as-headed" condition, they could be upset in this way to 1.3 D when annealed after heading, provided they were not overdriven. Using a compression-type portable squeezer of 6000-lb. capacity, however, solid titanium rivets of ⅛-in. or 5/32-in. diameter, both as-headed and annealed, were successfully upset to 1.5 D with satisfactory hole filling.

Single-shear strength tests were made on specimens of commercially pure titanium sheets riveted with universal head and 100° countersunk head titanium rivets of several grades. These rivets developed about 10 to 15% higher static strengths than Monel metal rivets of the same size, though they weighed about 50% less.

Fatigue tests were made on separate titanium and stainless steel sheet specimens, lap jointed and riveted either with universal head or countersunk head rivets of titanium and Monel metal. With countersunk heads, the fatigue strength was comparable for both kinds of rivet, but with universal heads the Monel rivets gave about 5 to 10% higher fatigue strength than the titanium variety. Some of the universal type of rivets of both metals lost their heads in the fatigue tests. Test results seem to indicate that improved fatigue strength is attained if the fillet radius between head and shank of the rivet is recessed further into the head to facilitate more complete bearing of the head against the sheet.

(Continued on p. 176)



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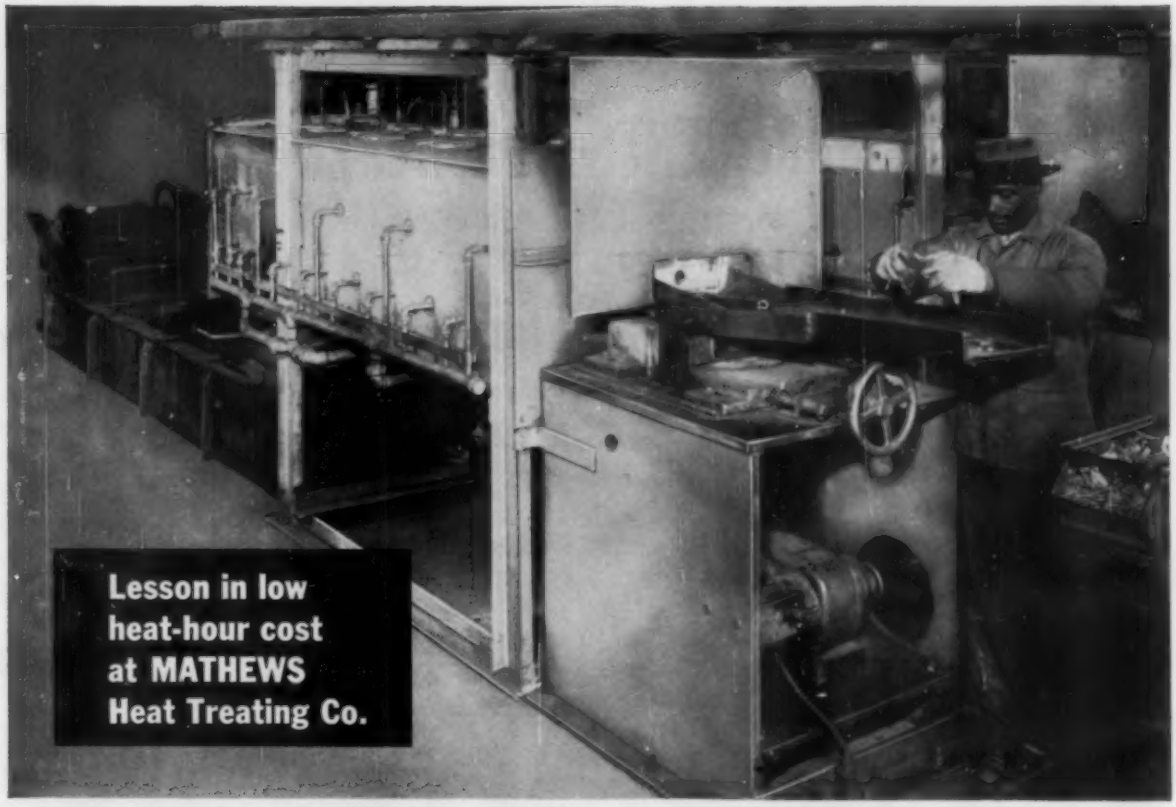

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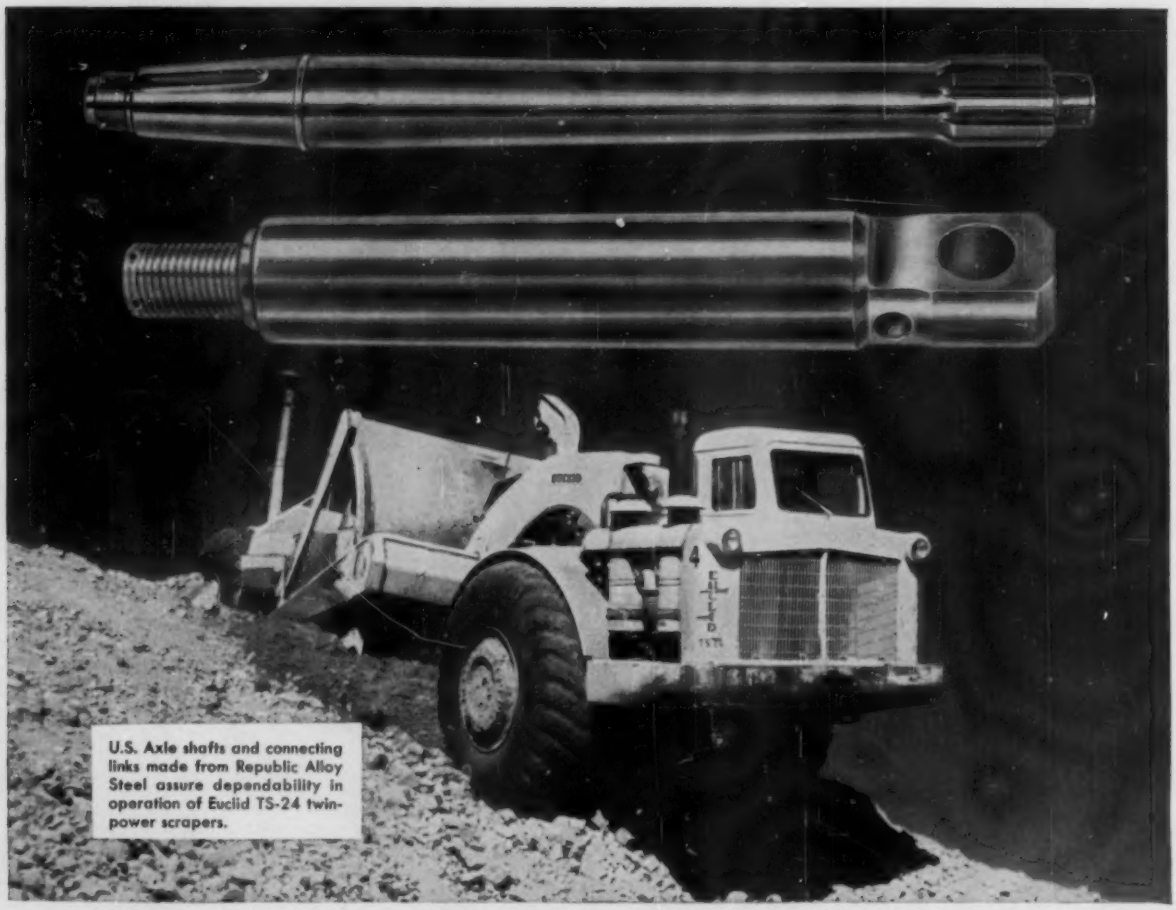

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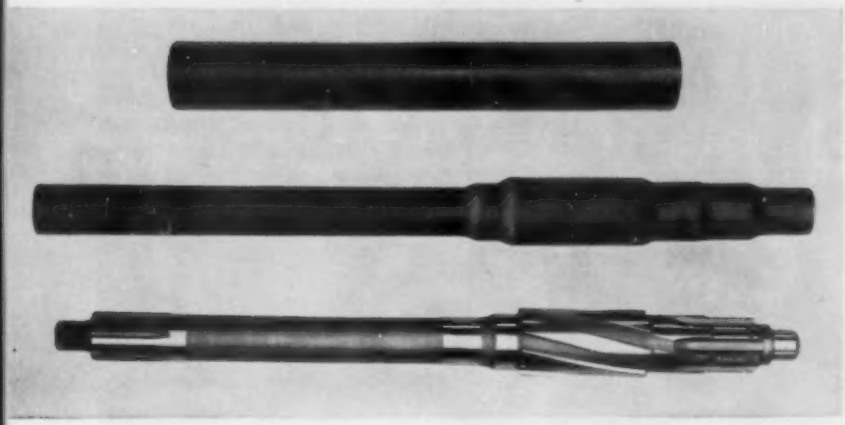

REPUBLIC DIE-FORM MEANS ECONOMY. This new fabricating process can save you 1 out of 3 tons of steel. The automotive transmission shaft, shown at left, proves the point. Using Die-Form, 200 tons of cold finished blanks produced parts formerly requiring 300 tons. Die-Form is a new method of cold forming hot rolled carbon, alloy, or stainless steel bars into multi-diameter blanks ready for final machining. It permits major savings in time, material, and money in mass produced, multi-diameter machine shafts. Since Die-Form closely approximates the final part, only finishing cuts and/or grinding are required for completion. Scrap loss is minimized—production rate increased. Send coupon for booklet describing the advantages of this new process.

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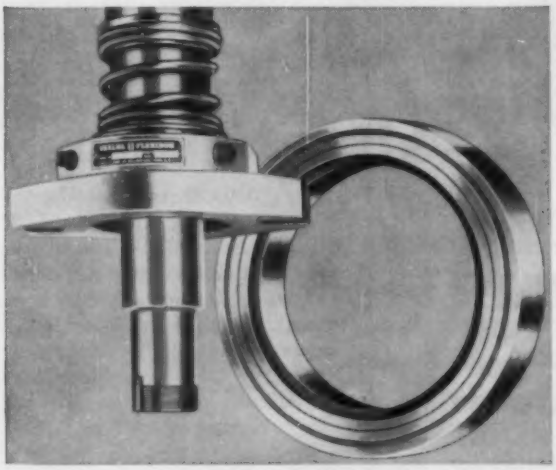

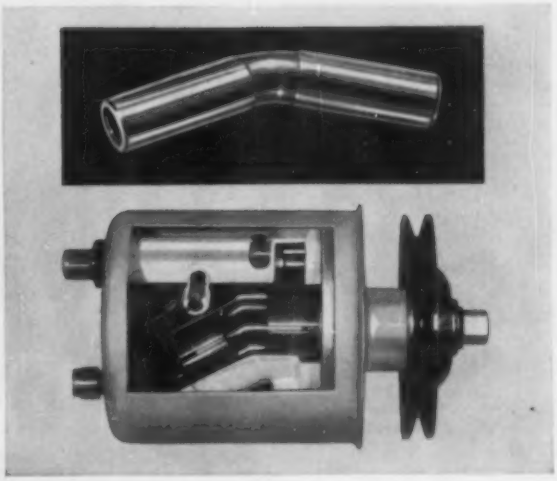

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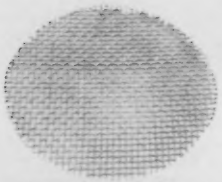

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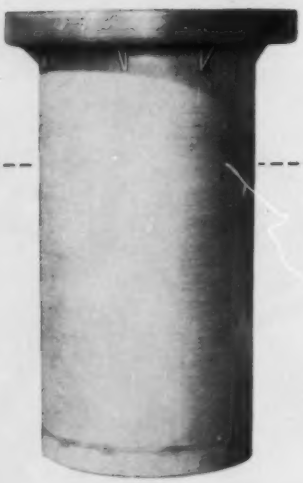

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Titanium Rivets . . .

Blind rivets also were joined successfully from titanium, having annealed and lubricated sleeves and serrations rolled on the stem to facilitate pulling action. Aircraft stabilizers are now in use made entirely of titanium and employing both solid and blind titanium rivets. Anodizing racks and orthopedic braces have likewise been constructed with titanium rivets.

Although hot driving of titanium alloy rivets has been accomplished, it is more likely that cold heading and upsetting will be relied on in the future, and a high-strength cold heading titanium alloy for rivets may be developed.

G. F. COMSTOCK

Solid Forgings from Compacted Scrap Turnings

Digest of "The Economic Industrial Utilization of Steel Swarf", by I. N. Goncharov and E. P. Semchenko, *Vestnik Mashinostroyeniya* (Russia), No. 2, February 1957, p. 80-84; translated and digested in *Engineers' Digest*, Vol. 18, June 1957, p. 243-244.

OVER 3,000,000 TONS of steel swarf (long or short turnings in U.S. parlance) are produced annually in Soviet machining operations. Steelworks are reluctant to handle such volume of loose material in melting furnaces because of the impairment of efficiency, lowered quality of output, difficulty of transport and loss through burning which runs to better than 30%. Hence other methods of utilization have been studied, including crushing for blast furnace charging; briquetting with various types of binders, then drying and annealing followed by baling, for open-hearth charges.

Special efforts have been directed to alloy steel turnings. Cutting oil mixed with this form of scrap yields an excessive carbon content which is burned away in a rotary furnace at 1300 to 1650° F. This reduces both carbon and sulphur permitting charging in electric furnaces, but the double processing is costly and results in some loss of alloy content.

A new process, evolved under laboratory conditions, proposes to forge weld steel turnings to produce

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Forging of Turnings . . .

both charging stock for electric furnaces and blanks which can be used directly for manufacture of machine components. Forge welding requires joining together cleaned turnings by hammering, after prior softening by heating. It is essential, of course, to remove metallic oxides from the surfaces with fluxes during heating.

In tests carried out at a locomotive plant on curled steel turnings, heated in a forging furnace using solid fuel, it was found possible to produce briquets and steel forgings, weighing 10 to 90 lb., with a single blow from a 2600 lb. drop hammer. Heating to 1550 to 1650° F. yielded briquets with specific gravity of 6.7 to 7.2; when the turnings were preheated to 1850 to 2000° F., steel forgings with specific gravity of 7.8 were obtained – equivalent to the normal specific gravity of steel. Heating required 5 to 9 min., caused a burning loss of 4 to 6%. Solid, dense forgings were produced not only from mild steel but also from medium-carbon and alloy steels.

In earlier tests, turnings were placed in cylinders fabricated from scrap steel sheet, into which they were first compacted by hand ramming. After heating, the cylinder and its contents were loaded into a cylindrical die of 4 in. diameter and further compacted by a drop hammer. A modification involved baling the scrap with thin wire and heating before forging. In both systems, good results are reported.

Mechanical properties of steel obtained by forge welding were said, in most instances, to be higher than those of the parent metal, impact strength in particular being almost doubled. Gear wheels were machined from such forgings.

Production installations include a rotary heating furnace designed to handle 5 tons of forgings hourly. Preliminary estimates indicate that the cost of producing these "swarf" forgings will be lower than the cost of swarf processing by other methods. It is also reported that cast iron turnings can be made into solid briquets.

Note: Some work of this type was carried out by the Chevrolet Divi-

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sion of General Motors Corp. about 15 years ago, producing small bearing ring forgings from steel turnings for use in automotive transmissions. While sound forgings were produced, the project never proved practical on a production basis, and was discarded.

ARTHUR H. ALLEN

Nuclear Power in Great Britain

Digest of "The Future of Nuclear Power", by Christopher Hinton. A lecture before the Royal Swedish Academy of Engineering Science, Stockholm, March 15, 1957; digested in *The Engineer*, Vol. 203, March 22, 1957, p. 442-444.

FROM the British experience gained in building and initially operating the Calder Hall reactor, the author examines proposed reactor designs for 1961 in the light of information available in March 1957. These designs are cognizant of the facts of life in the United Kingdom, characterized by the absence of large plants for separating the fissionable isotope of uranium and the rising equivalent cost of coal, which has doubled there in the past quarter century.

It is felt that the present Calder Hall design is sufficiently conservative from the material point of view to support a temperature increase in the canning material from the present 765° to 840° F. by improvements in mechanical design. Experience with magnesium alloys and their further development is expected to push allowable can temperatures to about 890° F. However, as the ratings of power density are rapidly and continually increasing, central uranium temperatures would be expected to increase to about 1470° F. if the present cylindrical fuel element design were kept. This increasing temperature trend, because of the uncertainties involved in crossing allotropic changes in uranium at 1220° and 1420° F., would therefore force a departure from the present fuel element design to a small rod, flat plate or tubular-type element.

Beryllium, in spite of development and toxicity problems, is conceived as the canning material. Magnesium limits temperatures at the can to

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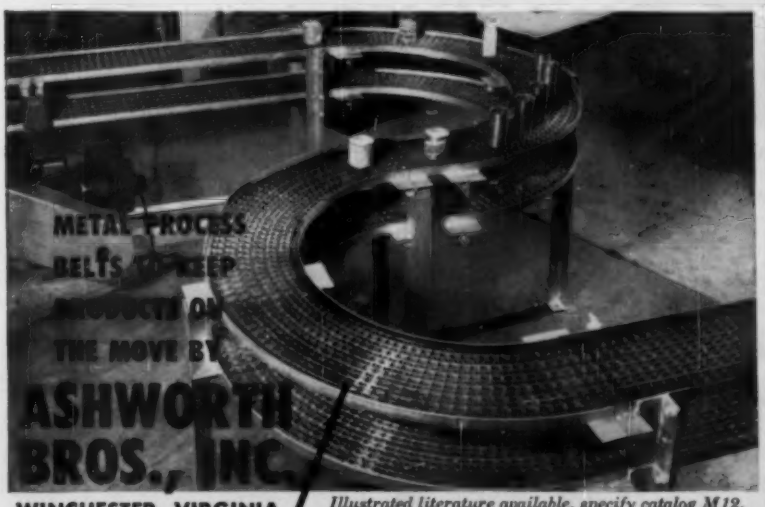

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Nuclear Power . . .

930° F. since it melts at 1200° F. Zirconium, very good in a water medium, is not acceptable above 930° F. in CO_2 because of oxidation. Beryllium has no reaction with dry CO_2 up to 2370° F. and forms no intermetallics with uranium. However, to depend on its restrictive ability to contain the distortions produced in metallic uranium would be unwise, and would likely force consideration of ceramics or semi-ceramics as fuel materials at these temperatures.

The accompanying pressure vessel design is expected to provide for increase in wall thickness from the present 2-in. maximum to one of 3-in. maximum. The X-ray examination of welds on site are becoming problematical at the present wall thickness and would become of increasingly questionable validity in a thicker vessel. A spherical-shaped vessel would assist in lowering the unit stress level in the projected design.

A substitution of helium for CO_2 as the coolant would eliminate all worries of chemical reactivity, but would render operation dependent upon United States sources. The use of hydrogen would provide higher heat transfer for the same circulatory power, but its pyrophoricity with uranium and embrittling effect on steel are well known. The author considers that these difficulties are not insuperable.

The projected capital costs of nuclear power for the next several decades is calculated to follow a course somewhere between the rapid cost reduction characteristic of the development of oil-fired plants and the less rapid reduction in the steam power stations, reaching, for nuclear types, about $220 per kw. of capacity by 1980. Allowance in this trend has been made for the fact that nuclear plants cannot always carry base load, and load factors have been assumed to be reduced as time goes on. Effects from cost of higher priced fuel elements are assumed to be more than offset by their longer life. The plutonium credit is assumed to diminish with time, as being dependent upon competitive power cost between thermal and fast reactors. The latter reactors, being plutonium customers of the former, cannot afford to pay more than the competitive power cost would dictate.

Based upon these capital cost forecasts, the price in U.S. mills (at $2.81 to the English pound) for one kw-hr. of nuclear-fueled electricity in Britain, exclusive of transmission costs, is estimated to be 7.7 in 1960, 5.5 in 1970, 4.5 in 1980, and 3.8 in 1990. This compares with a projected cost of coal-fired electricity of 7.0 in 1960, 7.8 in 1970, 8.5 in 1980, and 9.8 in 1990.

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Cohesive Strengths of Metals

Digest of "Tensile Fracture of Ductile Metals", by H. H. Bleakney, *Canadian Metals*, Vol. 20, February 1957, p. 60-64.

THE BONDING of atoms in metals is about 20 to 100 times the observed strength of metals in ordinary tension tests. Estimates of the theoretical cohesive strengths of metals were made 30 years ago. From consideration of the heat of vaporization of metals, their tensile strengths were estimated: a value of 4,700,000 psi. was established for iron. Similarly high values were obtained by applying data on atomic

(Continued on p. 184)

Firth Sterling ...

PIONEER IN POWDER AND MOLTEN METALLURGY

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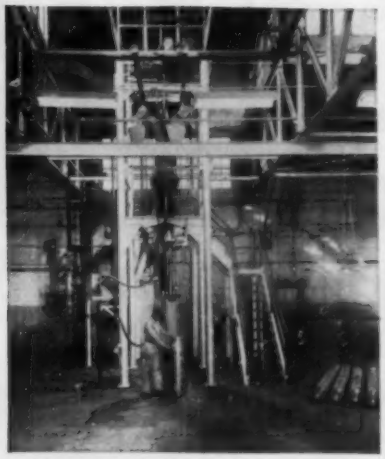

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(STERCON)

INDUCTION VACUUM
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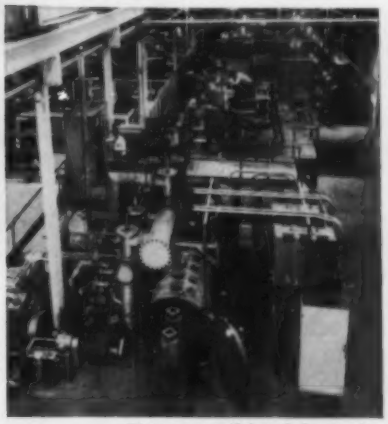

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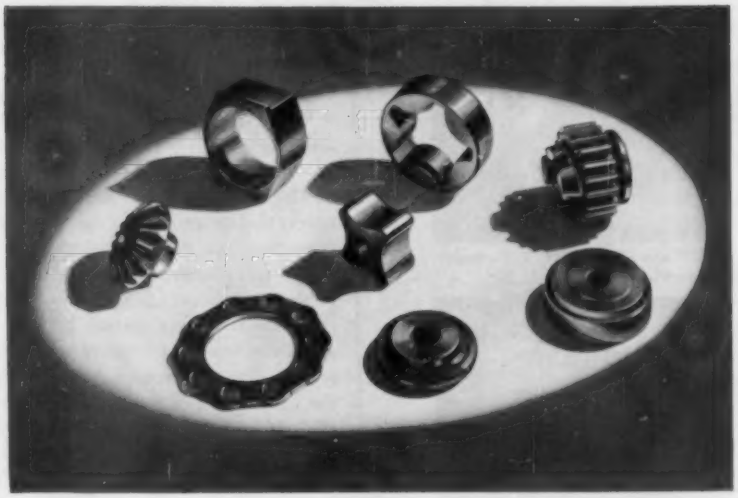

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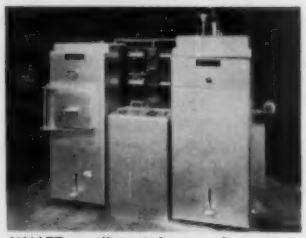

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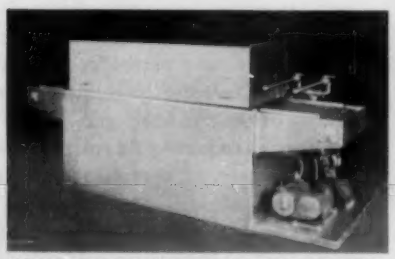

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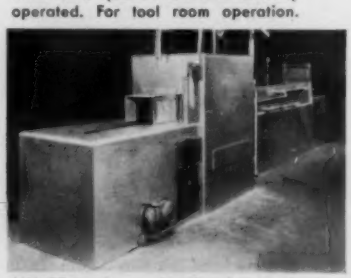

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Cohesive Strength . . .

volumes, co-efficients of expansion and compressibility to an equation of state for solids.

The now famous Griffith's microcrack theory provided the first explanation for the discrepancy between the theoretical and technical cohesive strengths of metals. He proposed that over minute localized areas the stress at rupture is much greater than the average stress across the full section of the piece because of the existence of stress-raisers which, he suggested, were microcracks. Moreover, he postulated that pre-existing cracks or fissures produced during the deformation of brittle components and weak interphases need not be present.

The author of this paper presents new evidence to show that shear fractures of ductile materials originate as minute fissures on the axis of the test bar which grow and progress toward the periphery at right angle to the axis. Results of tensile tests on various materials show three modes of fracture:

First, fractures with 100% reduction of area occurred in pure aluminum at 500 and 600° F., and in low-carbon steel at 1800° F. In both cases, materials of high purity were used. Tests with 1100 (2 S) aluminum alloy revealed the detrimental effect of impurities on ductility at given temperatures. (Most metals show 100% reduction of area above their recrystallization temperatures.)

The second type of fracture was a slowly growing fissure. Radiographs obtained on specimens of 1100 aluminum alloys stressed between the ultimate stress and complete fracture revealed evidence of the slow spread of a crack formed on the axis of the specimen.

Finally, a third mode of fracture was described whereby an internal fissure on the axis of the specimen grew almost instantaneously to the outer periphery of the specimen. Evidence for this mode of fracture was obtained by examination of specimens deformed past the ultimate strength by means of high speed moving pictures of specimens during fracture.

The inhibition of metal flow by work hardening and triaxiality of

(Continued on p. 188)

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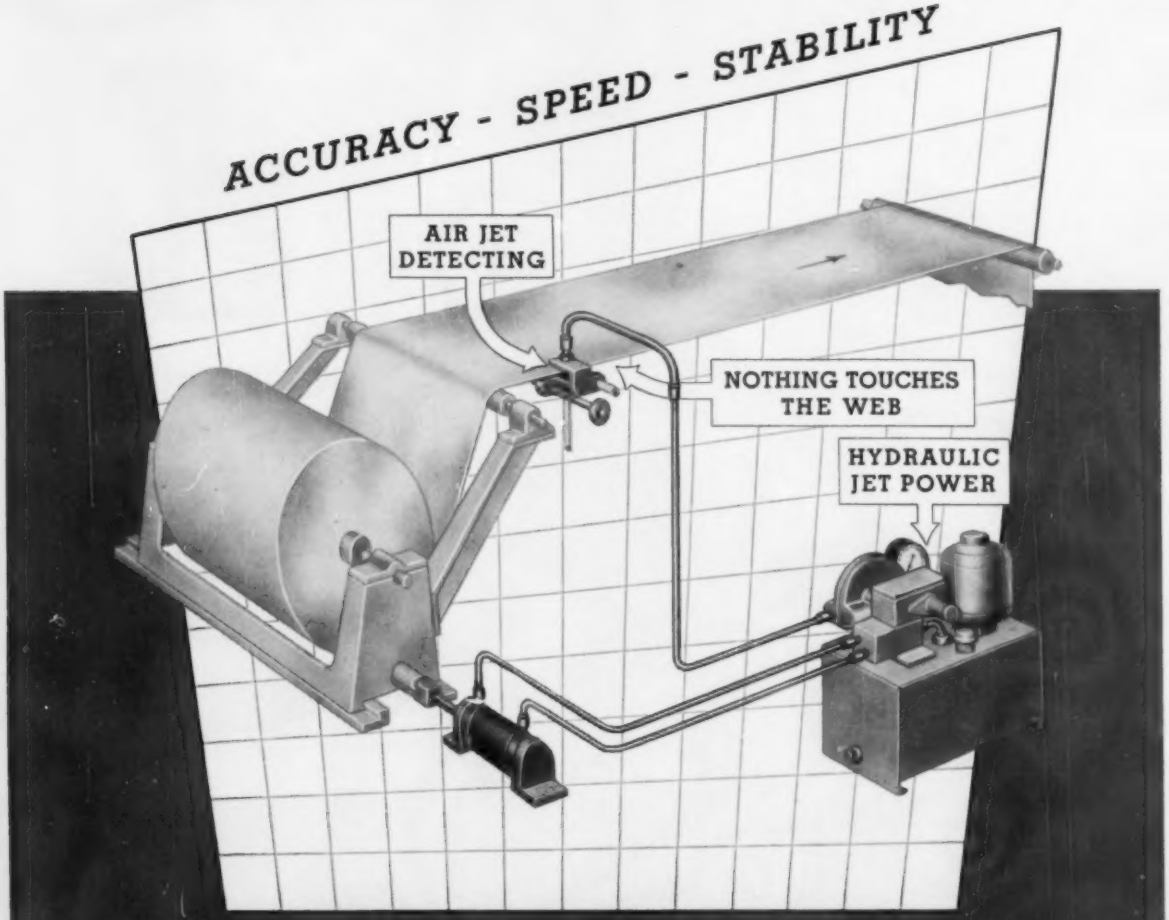

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Chromel-Alumel thermocouple alloys are unconditionally guaranteed to register true temperature—e.m.f. values within close specified limits . . . ±4°F. from 0° to 530°F.; ±¾% at operating temperatures from 531° to 2300°F.

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Despite their finer accuracy, higher temperature range, and longer useful life, Chromel-Alumel thermocouple wire costs the user no more than ordinary base metal materials . . . and in many cases, they actually cost less!

Ask for them by name! Your instrument manufacturer or pyrometer service company can supply your immediate requirements for plain or insulated wire and assembled couples. So ask for them by name . . . "Chromel-Alumel" thermocouples . . . trade names you can trust!

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3 It took Bill two hours to drive to the plant through the storm. He spotted the trouble immediately; a thermocouple and its protecting tube had burned out. It might have meant four to five thousand dollars' worth of damage.

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- Application engineering for installation and startup.
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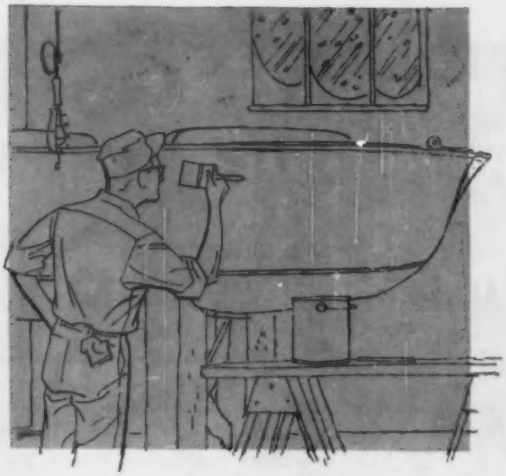
- Training of your operators at the Honeywell Instrumentation Education Center.



1 Bill Lewis, service engineer at Honeywell's Fort Wayne branch, was in his garage, touching up the paint on his 13-foot outboard. The bowling match had been called off that night because of the snowstorm, and Bill was glad to be home.

2 At 9:30 a call came from the Crosby Laughlin Division of American Hoist and Derrick Company in Fort Wayne. A controller on a galvanizing kettle wasn't working and unless it was fixed fast, the pot would either freeze or burn out. Bill said he would be out right away.

4 Bill didn't have a thermocouple with him that would fit, so he improvised a temporary couple and protecting tube and got the system going. Early the next morning he called the Honeywell branch in Indianapolis and had the correct thermocouple and tube shipped quickly to the plant. Next day, he carefully checked out the entire installation.

5 Now, Crosby Laughlin Division is signed up with the Honeywell Periodic Service Plan, and its complete instrumentation is checked and serviced every month. Any spare parts needed are now available at Honeywell's Fort Wayne branch. Bill hasn't had to make another emergency call to the plant since.

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Cohesive Strength . . .

stress is briefly discussed. The mechanism of the cup and cone fracture is viewed as the spreading of the original crack in a different direction in response to new stress distribution requirements. Figures reported as the true fracture stress in tension have little significance. The true stress at fractures has not yet been determined experimentally. In the first mode of fracture described, where 100% reduction of area is obtained, the stress at fracture is obviously indeterminate. In the other instances, the stress is not uniformly distributed and it is impossible to determine the exact value of the load at which the first fissure is formed.

It appears that no real discrepancy has been observed between the true cohesive strength of materials and their actual breaking strengths.

H. P. TARDIF

Bismuth Alloys

Digest of "Bismuth Recovery at Oroya", by Walter C. Smith and Philips J. Hickey, presented at the annual meeting of the A.I.M.E., New York, February 16 to 20, 1958.

MOST USES of bismuth alloys hinge on somewhat unique properties which are modified according to the kind and percentage of the alloying components. For example, some of the alloys containing lead expand during solidification and grow during and after cooling to room temperature. Some of these do not become completely stable in less than 500 to 700 hr. after casting. Other bismuth alloys without lead, although they expand during freezing, show negligible shrinkage while cooling to room temperature and exhibit no growth in the solid phase.

Actual and potential applications of bismuth combined with varying proportions of lead, tin, cadmium, indium and other metals include the following: Anchoring of bushings and bearings, chucks, cores, dies, punches, models, patterns, molds for casting or forming of low temperature plastics, filler for tube bending, sealing joints of glass and glass or glass and metal. Bismuth telluride has considerable promise as a semi-conductor.

Some typical Cerro alloys, with their melting ranges and yield temperatures, are listed below:

NAME	MELTING RANGE	YIELD TEMP.
Cerrolow-105	100-110° F.	105° F.
Cerrolow-117	117-117	117
Cerrobend	158-158	158
Wood's Metal	158-165	158
Cerrosafe	160-190	165
Cerrodent	167-244	181
Cerromatrix	217-440	241
Cerrobase	255-255	255
Cerrotru	281-281	281
Cerrocast	281-338	302

A market of potentially large proportions shows signs of developing for refined bismuth. The atomic energy industry is currently using some bismuth in liquid metal cooled reactors and for shielding. It can be assumed that, if these reactors are successful and commercial power stations of this type are erected, bismuth will be in short supply.

In connection with atomic energy uses of bismuth, some of the anticipated future need will be for metal of extreme purity. Even bismuth, which contains less than 15 ppm. of total impurities, is not considered sufficiently pure.

Studies now underway indicate that the costs of upgrading the present product will be very high, but granting sufficient demand, the necessary techniques can be mastered.

A.G.G.

5 Basic Reasons why
MARVEL HACK SAWS
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The consistently accurate performance of MARVEL Heavy Duty Hack Saws is no accident. MARVEL engineers knew, many years ago, that to produce and maintain accurate cutting-off, a hack saw must be designed and built like a fine machine tool.

Some of the basic design principles built into the modern MARVEL Hack Sawing System that makes it the most accurate cutting-off method you can use are:

1. V-Way Design...Greater Rigidity
Upright and Saddle are precision machined and fitted to form a rigid, integral unit capable of withstanding any cutting load with no deflection or side movement.

2. Anti-Friction Bearing Construction
Anti-friction ball or roller bearings are used at all load carrying points. Even the strongly braced saw frame reciprocates on heavy duty, fully enclosed preloaded ball bearings which provide permanent, frictionless rigidity and true-running, straight line cutting strokes.

3. Minimum Blade Frame Reach
Close-coupled design and crank lever action of MARVEL Saws keeps the saw frame and blade reach very short in relation to the vertical V-ways on which the unit is mounted. This insures optimum rigidity, even under the most severe operating conditions.

4. Positive Relief Blade Lift
On the return stroke, positive relief lift raises the blade to provide proper and "cushioned" lead-in on the next cutting stroke. This prolongs blade sharpness, life and accuracy.

5. Rigid Cutting Tool
Cutting-off accuracy requires a rigidly held, relatively short cutting tool. MARVEL Unbreakable High-Speed-Edge Hack Saw Blades, which combine a narrow high speed steel cutting edge permanently welded to a tough alloy steel body, can be tensioned from 200% to 300% more taut than ordinary blades. This provides a most rigid cutting edge.

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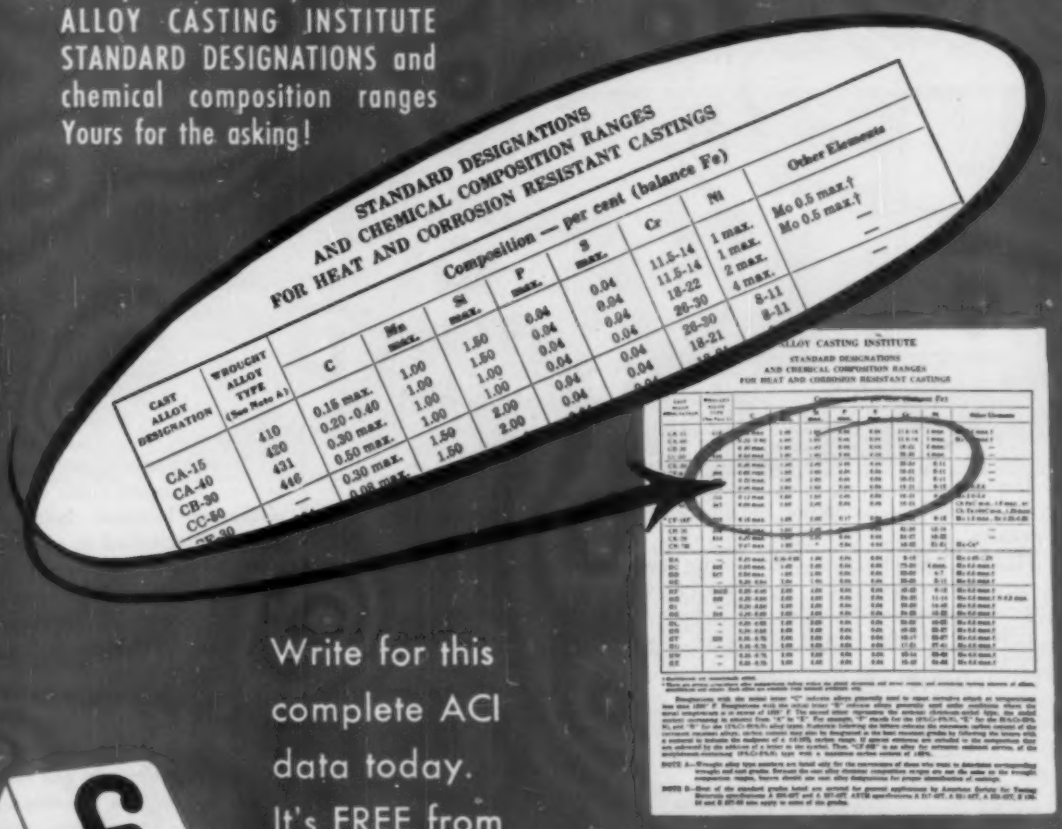
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CAST ALLOY DESIGNATION	WROUGHT ALLOY TYPE (See Note A)	Composition — per cent (balance Fe)						
		C	Mn max.	Si max.	P max.	S max.	Cr	Ni	Other Elements
CA-15	410	0.15 max.	1.00	1.50	0.04	0.04	11.5-14	1 max.	Mo 0.5 max.†
CA-40	420	0.20-0.40	1.00	1.50	0.04	0.04	11.5-14	1 max.	Mo 0.5 max.†
CB-30	431	0.30 max.	1.00	1.00	0.04	0.04	18-22	2 max.	—
CC-50	446	0.50 max.	1.00	1.00	0.04	0.04	26-30	4 max.	—
CE-30	—	0.30 max.	1.50	2.00	0.04	0.04	26-30	8-11	
		0.08 max.	1.50	2.00			18-21	8-11	

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Surface Hardening by Induction Heating

Digest of "The Application of Induction Heating to the Surface Hardening of Steel", by J. Hamilton, *Metallurgia*, Vol. 55, January 1957, p. 3-7.

IN DESIGNING steel components for engineering applications, it is often necessary to rely on a hardened surface supported by a relatively soft core. Carburizing will do this, and so will nitriding. Another method is to use a hardenable steel and preferentially (locally) heat the surface rapidly so that only a thin layer achieves hardening temperature and the core is left unaffected when the part is quenched. The rapid heating of the surface requires a high rate of energy output and a convenient means of achieving this is to induce electric current to flow in a shallow surface layer utilizing the basic principles of induction heating.

In induction heating the part to be heated becomes the secondary of a simple transformer circuit with the inductor acting as primary through which the high frequency alternating current passes and within which is set up a magnetic field. The part being heated is placed within the coil and the coil's magnetic field induces currents to flow in the part and in a direction opposite to that of the coil current. The flow of current in the piece being heated becomes weaker with increased depth due to a weaker magnetic field. The higher the frequency the more pronounced this weakening effect and the current density falls rapidly with increased depths according to a logarithmic equation. It is this tendency for the current to flow on the surface and thus generate the heat in the surface as a result of I^2R losses that is referred to as "skin effect". To achieve the desired heating rate, a power input of up to 25 kw. per sq.in. may be required and for such high densities a single-turn coil is better.

With single-turn coils, high-frequency transformers are used to reduce the voltage of the high-frequency energy. Multiturn coils are also used with transformers unless full generator voltage is required in which case the coil is connected directly across the output of the generator. Coils are water cooled, and clearance between inductor and work is maintained as small as possible without introducing loading problems. For single-turn inductors, this is generally between $\frac{1}{16}$ in. and $\frac{1}{8}$ in., and quench water is normally applied through holes in the inductor leading to a separate water passage.

The available sources of high-frequency power are generally motor-generator sets, vacuum tube oscillators and spark gap oscillators. Motor-generator sets are available in frequencies varying up to 10,000 cycles and in sizes from a few kilowatts up to several hundred kilowatts. Vacuum tube oscillators normally operate at 400,000 cycles per sec. and are available with outputs up to 160 kw.

The first consideration in deciding which type of generating equipment to be used is the technical aspects

In the Final Analysis..

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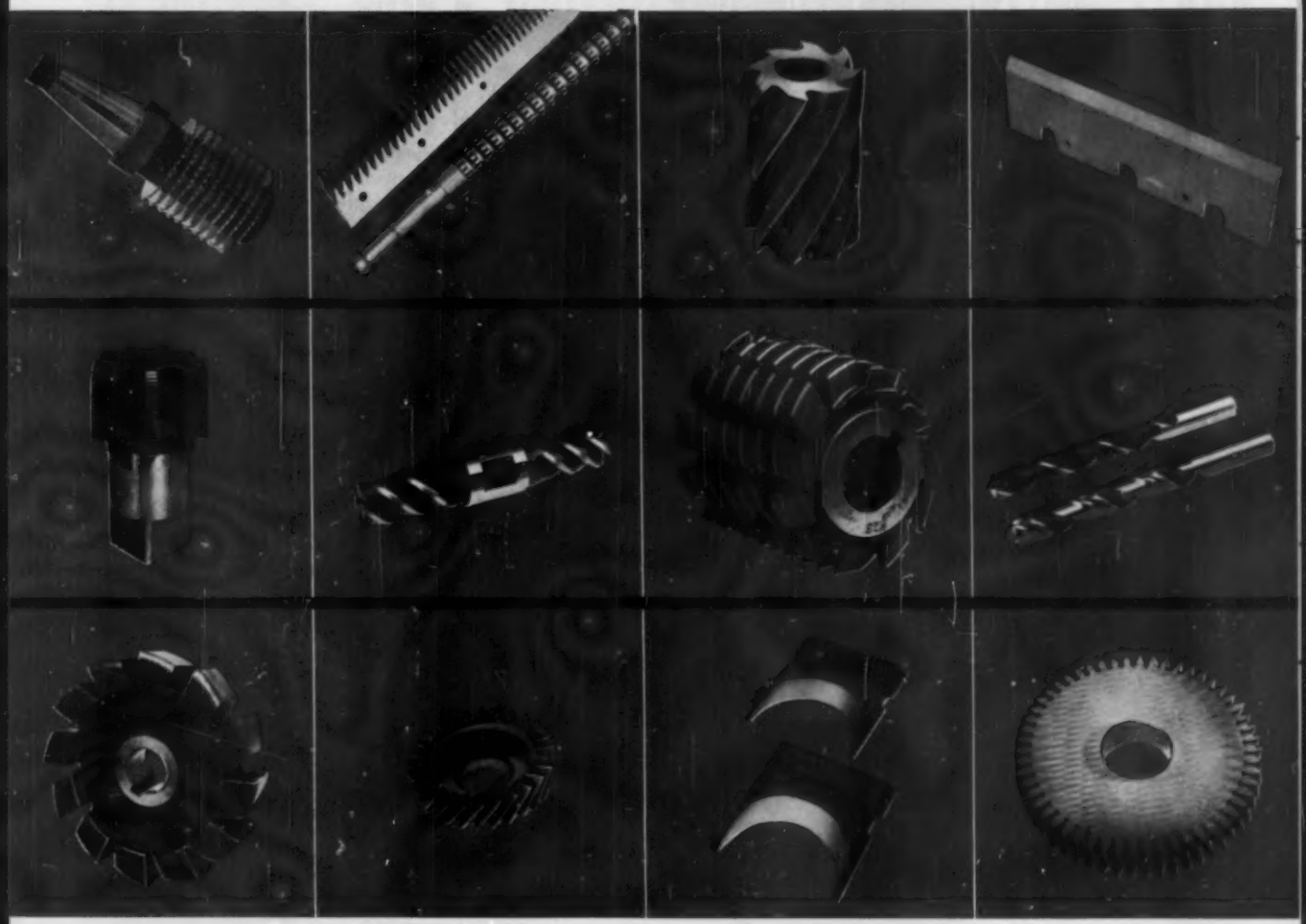

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STOKES

Surface Hardening . . .

of the problem. There is a minimum depth which can be obtained for each frequency. For example, if a shallow case such as 0.025 in. is required, a vacuum tube oscillator should be used, whereas if a case depth of 0.060 inches and upwards is permitted, a motor-generator set operating at 10,000 cycles can be used.

For single-shot surface hardening, the heating time decreases and the power input increases as the frequency is reduced, so that in some cases a vacuum tube oscillator of given capacity can do the same job as a motor-generator set of larger capacity.

There are many equations which can be applied to the evaluation of induction heating applications. These take into consideration such factors as the resistivity of material, its magnetic permeability, depth of penetration of the magnetic flux, and effect of temperature and time. However, a few simple empirical equations can be applied which are helpful in evaluating the effect of frequency and heating time.

$$D = \sqrt{4/F}$$

For all practical purposes D is the depth in inches, in which the current is flowing, and F equals the frequency in cycles per second.

The heat generated in a piece of magnetic steel heated to hardening temperature is not dependent only upon frequency. Additional depth results in heat flow by conduction and follows the equation:

$$D = \sqrt{.0015T}$$

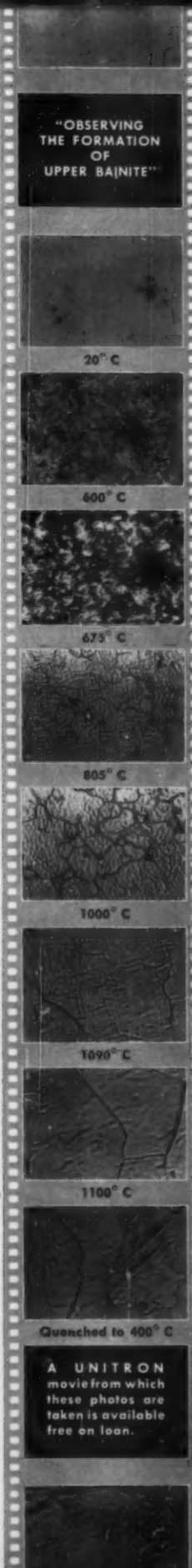
where D equals depth in inches, and T equals time in seconds. Thus, by knowing the frequency and the heating time, the sum of the above equations will come pretty close to predicting the actual heated depth.

The power required for surface hardening depends on the hardened depth and the area to be treated. The following equation is a helpful guide to the energy required:

$$E = 320V$$

where E equals energy in kilowatt seconds, and V equals volume of material to be hardened in cubic inch equivalent (depth of hardness multiplied by the hardened area).

Occasionally it is necessary to surface harden long areas and to do



See What Happens to Metals at High Temperatures with a *UNITRON* VACUUM HEATING STAGE

- Fits any inverted metallograph or microscope
- Tungsten furnace element attains temperatures to 1100°C
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- Provision for quenching from higher temperatures
- Built-in thermocouple
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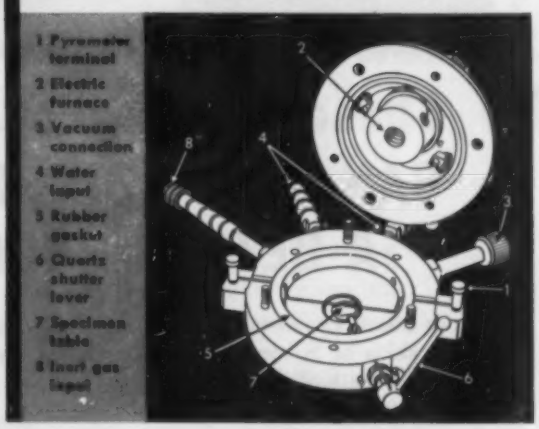
UNITRON Vacuum heating stage mounted on UNITRON Inverted Metallograph



Observation of metals at room temperatures is limited to structures which are stable under these conditions or available in metastable state by quenching from higher temperatures. The UNITRON Vacuum Heating Stage adds a new dimension to the microscopy of metals in that specimens may be examined continuously at temperatures up to 1100°C. This permits the study of structural changes such as recrystallization, grain growth, thermal etching of fatigue cracks, precipitation, and phase transformations at the temperatures at which they occur. Quenching of the metal from any given temperature is accomplished by introducing a blast of inert gas. Observations may be photographed on motion picture film to provide a continuous record of the transition process during structural changes, or single exposures may be taken.

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UNITRON VACUUM HEATING STAGE, complete with built-in thermocouple, compensating wires, extra furnace with tungsten element, spare quartz windows and rubber gaskets, tools, in fitted hardwood cabinet . . . . . $535 FOB BOSTON

Accessory FF40X objective $149

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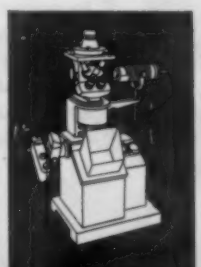

UNITRON Metallographs, priced from $1195 and Inverted Metallurgical Microscopes priced from $399, are designed to accommodate the VACUUM HEATING STAGE and long working distance objective.

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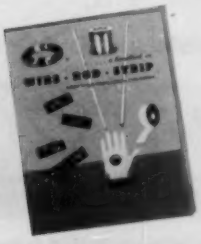

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Surface Hardening . . .

this by the static method is impractical. A simple means of overcoming this difficulty is to heat a narrow band around the part moving at a constant speed through the inductor and thence into a quench. When heating long shafts, it is necessary to rotate them during the operation to minimize distortion. Suitable inductors can be designed to use this same progressive technique on flat or even spherical surfaces and on the profiles of irregular objects such as cams or gear teeth.

The beneficial results of hardening gear teeth are quite obvious, and induction hardening provides a convenient method of hardening the teeth and leaving the body of the gear relatively soft. It is seldom practical to use an inductor formed into the valleys between the teeth since it is advisable to rotate the gear during the heating operation to provide for uniform depth of hardness and to prevent distortion. Uniform heating of the teeth, however, can be obtained by appropriate selection of frequency which will depend on the tooth form. Generally speaking, a frequency that is too high for the particular gear will tend to heat only the tips of the teeth. A frequency which is too low will tend to heat only the valleys between the teeth. The correct frequency will heat the tips, sides, and the valleys at the same time. If the correct frequency is selected and the heating is very rapid (plenty of power available), a contour approaching that of carburizing results. However, for practical reasons the use of an intermediate frequency can produce an acceptable pattern. This involves hardening of the valleys between the teeth and hardening of the tips and sides of the teeth down to approximately the pitch diameter.

The construction of inductors requires consideration of such things as contouring to follow the profile of a cam being hardened, the use of contacts which can open and close to permit the encircling of a bearing area having cheeks on either side (a crankshaft bearing), the addition of laminated materials to restrict the flow of induced current in the core of the material and provide a path

for the flux so that it can more effectively flow in the work. These are all part and parcel of the design features of inductors.

The various types of equipment used for applying the principles described above include all the necessary controls to make the process one which is completely automatic. A typical example is a 50-kw. vacuum tube oscillator for hardening automobile camshafts. It utilizes three split-type inductors with closing mechanism, a supporting carriage for indexing against automatic stops which locate the cams and bearings in the appropriate inductor, the heating and quenching controls working from timers and automatic rotation of the shaft to insure that each cam is positioned within the inductor.

H. B. Osborn, Jr.

Rupture Mechanism

Digest of "A Morphological Study of Rupture Surfaces by Electron Microscopy", by J. Plateau, G. Henry and C. Crussard, *Revue Universelle des Mines*, No. 10, October 1956, p. 543-554.

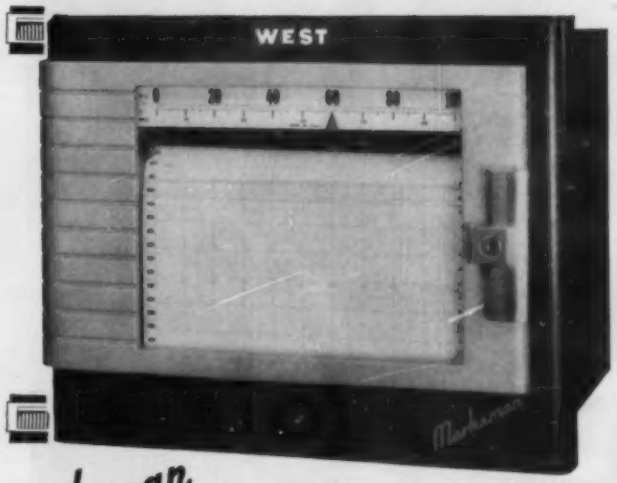
The large field depth of the electron microscope, added to its high resolving power, makes it suitable for the examination of all types of rupture surfaces. Tests, mainly of ferrous materials, were made at room and low temperatures.

In ductile ruptures, where the breaking stress is approximately normal to the surface, the structure consists of many side-by-side "cupules" (crystal cups), the sides of which were torn out in the last stages of fracture. A ductile rupture originating from nonmetallic inclusions or precipitates existing at the bottom of the cupules is caused by the joining of a series of holes initiated by the inclusions. A microfractograph representing the ductile zone of an austenitic steel specimen ruptured by bending at -320° F. has enabled the crystallographic plane along which the initial decohesian starts to be specified.

Ruptures by shearing failure have the same morphology with the difference that the cupules are elongated along the direction of the crack propagation.

Rupture surfaces of a number of steel specimens containing cleavages

how many?



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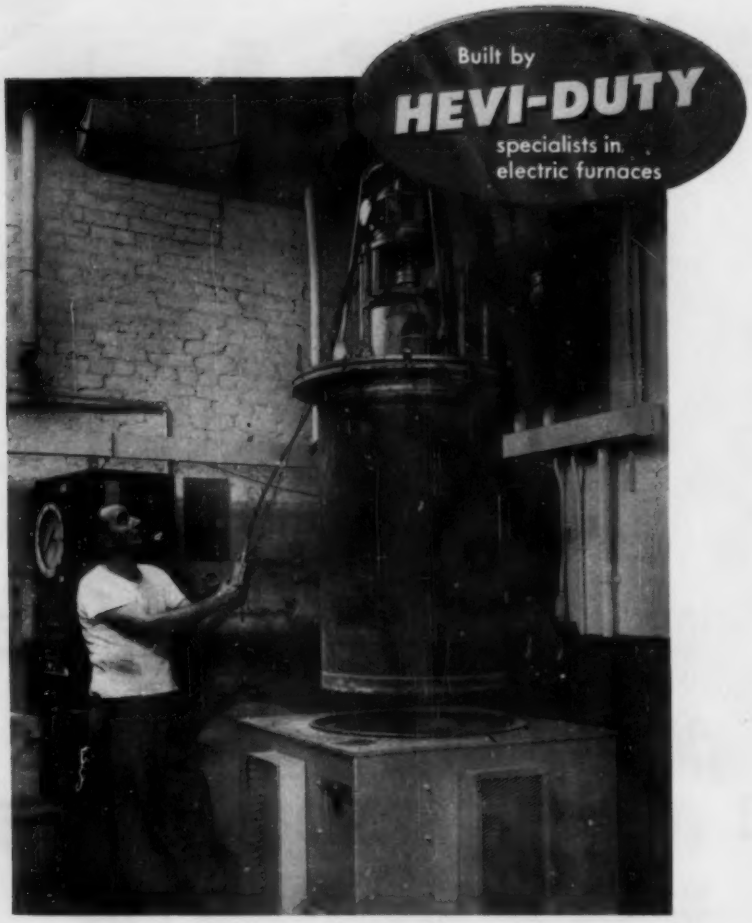


Two Retorts Double the Furnace Output at Cannon Electric Company

Cannon Electric Company, Los Angeles, age hardens as many as 150,000 beryllium copper springs in a single retort load, while a second retort slow cools with the springs protected by a special atmosphere. This produces bright, scale-free parts, yet permits constant use of the furnace. The Company chose a Hevi-Duty "Versa-Duty" pit furnace to do this double duty for several reasons:

They like its excellent uniformity. Temperature variations are held within plus or minus 10° F. despite the dense load. They like the fact that the fan is installed in the cover for easy servicing. They also appreciate its low maintenance. It has required nothing but normal lubrication since it was installed.

For more information on "Versa-Duty" pit furnaces, write for Bulletin 755.

- Heat Processing Furnaces
- Dry Type Transformers
- Constant Current Regulators

HEVI-DUTY ELECTRIC CO.
Milwaukee 1, Wisconsin

Rupture Mechanism . . .

are interpreted as follows: Most of the cleavage facets are streaked with steps which flow along the direction of the rupture propagation. In the same grain the tearing of a lamella separating two parallel cleavage planes produces a step. Within a grain a step is produced when a cleavage plane cuts a screw dislocation, the height of the step being equal to the Burgus vector. Elsewhere some of these steps start from a well-defined line. This feature is attributed to the crossing of a grain boundary or sub-boundary. The number and continuity of such steps is considerably increased when cold working precedes final breaking.

On the cleavage facets of very low-carbon steels, tiny tongue-like strips having a fixed crystallographic orientation with respect to the cleavage plane are frequently observed, except when severe work hardening is induced prior to fracturing. In the latter case a new kind of rupture surface free from steps appears. It is referred to as a "ductile cleavage" and is formed by the decohesion of deconsolidated slip planes. The general aspect of fatigue ruptures is said to be of this type.

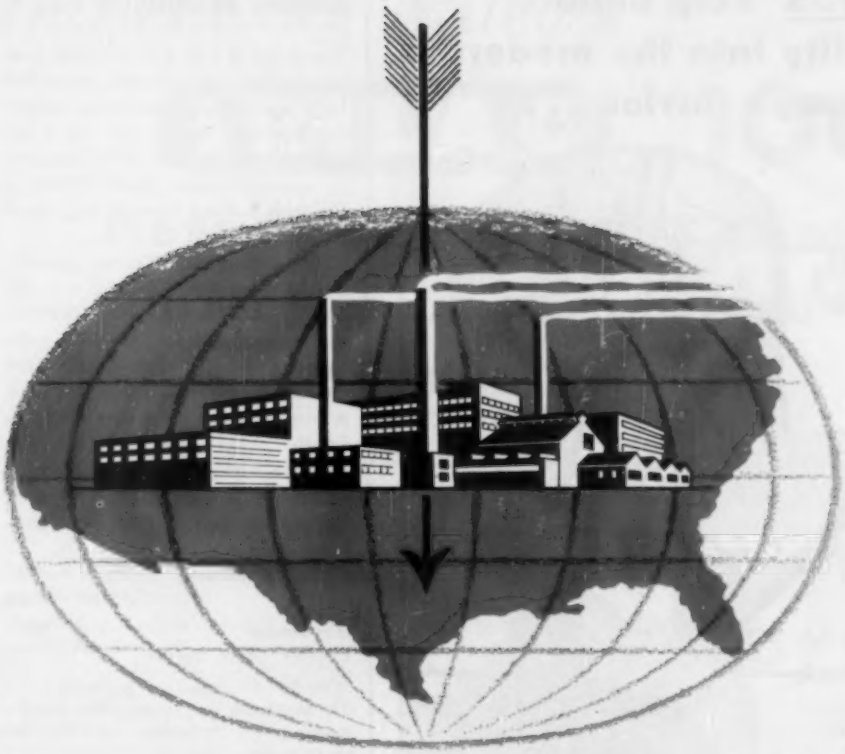
Moreover, the authors have gathered a considerable amount of information on the morphology of micro and submicroscopic inclusions (ductile ruptures), intercrystalline precipitates (intergranular ruptures), and mechanical twinning. Another application consists in deeply etching a brittle rupture surface before making a carbon replica of that surface. The metal structure is thus revealed in an easier and more rapid way than a similar structure obtained by the direct replica techniques.

PIERRE CHOLLET

Electric Discharge Machining

Digest of "Sawing Radio-Active Metals by the Arc-Process", by F. Bevilacqua, *Metalworking Production*, Vol. 101, Jan. 4, 1957, p. 11-13.

A GOOD WAY to cut radioactive test specimens, handled by remote control, is to use electrical discharges from a slowly rotating metal disc in a bath of dielectric fluid.



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The metal is held in a stainless steel vise by holddown fingers controlled by a manipulator extending outside the shielding cave. The vise is insulated from the rest of the machine by a polyethylene plastic lining in the tank holding the dielectric fluid and the vise.

The cutting disc, 6 in. in diameter and $\frac{1}{16}$ in. thick (material not disclosed), must have less than 0.0005-in. eccentricity or wobble. Although prevented electronically from contacting the workpiece, the disc is worn away at rates depending on *(a)* the metal from which the disc is made, and *(b)* the characteristics of the metal being cut. Approximate cutter to workpiece wear rates are:

Material	Wear Rates	
	Cutter	Work
Aluminum	1	15
Copper, brass, bronze	1	2
Stainless steel	1	1
Toolsteel	¾	1
Stellites	1	1
Tungsten carbide	3	1
Uranium	1	2

Transformer oils and silicone oils are satisfactory dielectric solutions. The latter are less liable to break down or form heavy sludge; they are obtainable in grades having a fairly high vapor pressure, but are expensive and hard to remove from the work. Carbon tetrachloride breaks down rapidly, promotes corrosion, and releases poisonous gases. Distilled water is advantageous in cutting uranium because it oxidizes the chips, preventing their combustion. Its resistivity may be lowered too much, however, by soluble impurities hindering the cutting action by dissipating electrical energy through the solution.

Uranium when cut with the aid of 93 μf. condensers connected across the electrodes, shows recrystallization within 0.01 of the cut surface; without condensers no recrystallization occurs. Fast cutting produces rougher cut surfaces than slower cutting action. Electric discharge cutting assures good control over contamination, since the chips are formed in liquid and are not, therefore, circulated in the surrounding atmosphere.

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New Clear Protective Coating for All Metals . . . as safe and easy to handle as Water!

New method of protection incorporates corrosion inhibitors in a water-soluble polymer base. Dries to an extremely thin, tough, durable coating—clear in color. Does not chemically affect base metal or any post-treatments. Used as a protective treatment alone or to enhance value of post-treatments.

Allied's new Irilac #1000 is a concentrated solution of a water-soluble polymer with built-in complex corrosion inhibiting materials. It was developed to answer the needs of the metalworking industry for a non-conversion process that will provide corrosion resistance and resistance to fingerprinting and abrasion on base metals and electrochemically or chemically finished surfaces—without changing the appearance of the metallic surface.

There are no hazards involved—Irilac is non-fuming, non-toxic, and requires no special fire prevention measures.

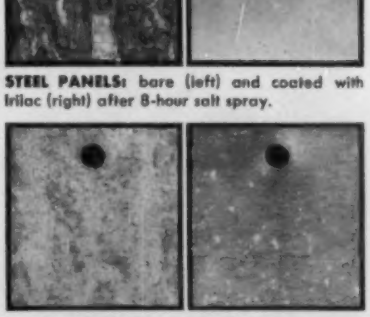
THE PROCESS

Irilac #1000 is diluted with water to provide a simple one-pass working solution. It is then applied by dip, brush or spray and forms a coating that quickly *bonds* to the metal surface without reacting with the surface.

THE PROPERTIES

The resulting coating is clear, transparent, thin yet durable. It has excellent water-resistant properties, and can be rubbed, handled and subjected to rough treatment. The surface to which Irilac has been applied is not altered—in fact, the transparent coating brings full tone to colored surfaces and clarity to iridescent surfaces. The water-thin physical characteristic of the solution means that the coating provides protection in recessed areas that are difficult, if not impossible, to protect with other methods.

STEEL PANELS: bare (left) and coated with Irilac (right) after 8-hour salt spray.



ALUMINUM PANELS: bare (left) and coated with Irilac (right) after 168-hour salt spray.

WHERE IRILAC CAN BE USED

Irilac #1000 can be applied to *any* metal—wet or dry—treated or untreated. All metals can be processed in *one* operation in the same solution. It can be applied in conjunction with any process—over Iridite, anodized, phosphated surfaces, black oxide, etc. Surfaces treated with Irilac provide a good base for paint.

APPLICATION ADVANTAGES

No other process or material available for the protection of metals offers all the application advantages found in new Irilac #1000:

1. It can be applied to *any* clean metal simply by dip, brush or spray. No special equipment is required.
2. Saves time—just apply and dry—no reaction time required.
3. No hazards involved—no exhaust or special fire protection equipment is required. Irilac is non-fuming and non-toxic.
4. Saves space. Presents no disposal problem. Low in first and final costs.

Because of its versatility and complete safety, Irilac has unlimited uses. For example, it will protect aluminum furniture, brass hardware and fixtures, steel parts of all types, zinc castings, etc. In fact, any base metal or plated surface, or those treated with electrolytic or chemical post-treatments, can be improved or enhanced with Irilac.

IRILAC #1000 MAY BE THE ANSWER TO YOUR PROTECTION PROBLEM

Our development staff will be glad to work with you to determine the significant benefits Irilac can offer you. Simply send us some parts and let us show you what Irilac can do. No obligation, of course.

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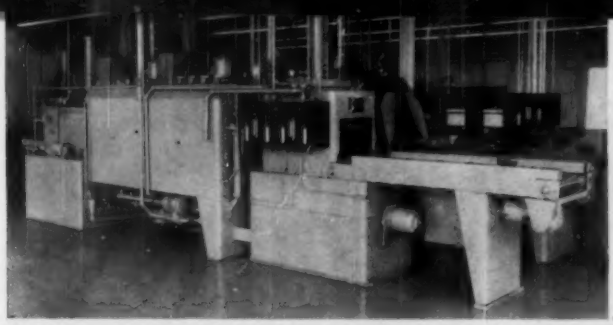
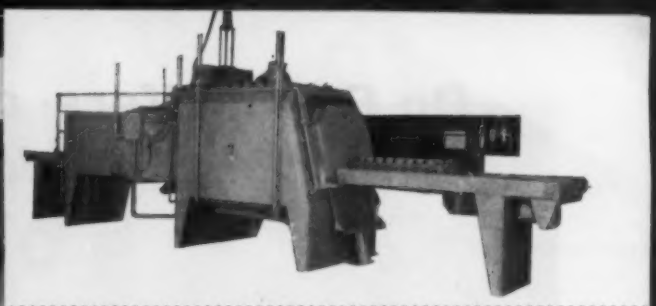
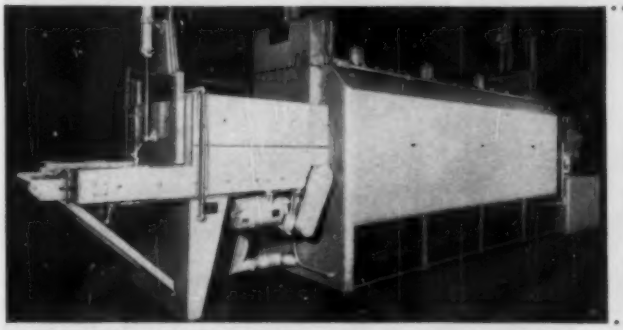


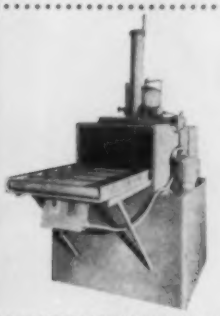
100% forced convection "straight-through" controlled atmosphere heat treating unit. Typical applications: carburizing, light case carbo-nitriding, neutral hardening, and marquenching. Available in 8 standard sizes from 150 to 2500 lbs. per hr. Ideally suited for automatic production lines.



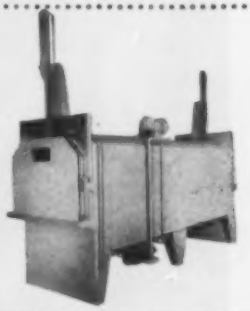
This "straight-through" furnace is for applications calling for controlled atmosphere cooling. These units have two-zone, water-jacketed, cooling chambers with forced convection cooling. Available in sizes to 1000 lbs. per hr. Heating is 100% forced convection with alloyed ceramic heating tubes.



Ipsen standard "pusher" furnace . . . multi-zone, controlled atmosphere furnace for carburizing, carbo-nitriding, and general heat treating. Has atmosphere purge vestibule sealed to charging end . . . oil quench enclosure at discharge end. Capacities from 400 to 4000 lbs. per hr.



Ipsen gas-fired washer for use with Ipsen automatic heat treating units. Drying available—rinsing optional. Available in four sizes—automatic or semi-automatic operation.



Designed for bright drawing and similar applications, this atmosphere tempering unit is available for capacities from 200 to 2000 lbs. per hr.

Ipsen OFFERS A COMPLETE LINE OF STANDARD CONTROLLED ATMOSPHERE FURNACES AND ACCESSORIES

Ipsen now offers America's most complete line of controlled atmosphere heat treating equipment . . . in *standard* designs, sizes, and types. Your furnace can be built immediately . . . no waiting while it's being engineered, because it's already engineered!

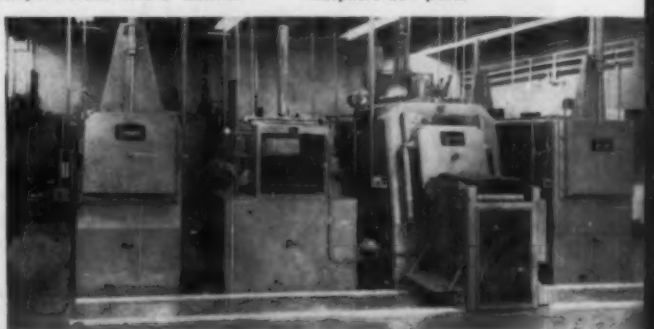
Standard Ipsen controlled atmosphere furnaces are available in more than 70 different sizes and types . . . from 4000 lbs. per hour controlled atmosphere units . . . to small laboratory furnaces.

Ipsen also offers a full line of standard, already engineered, semi-automatic loading and unloading equipment . . . dew point and carbon potential controllers . . . atmosphere generators . . . washers and related equipment.

Pictured on this page are a few of the many standard units offered by Ipsen . . . descriptive literature available upon request.

Endothermic controlled atmosphere generator. Ipsen also makes exothermic generators; ammonia dissociators. 11 sizes—250 to 2500 cu. ft. per hr. Gas-fired or electric.

Ipsen "Carbotronik" (left) automatically controls carbon potential of furnace atmosphere. "Dewtronik" (right) automatically controls atmosphere dew point.

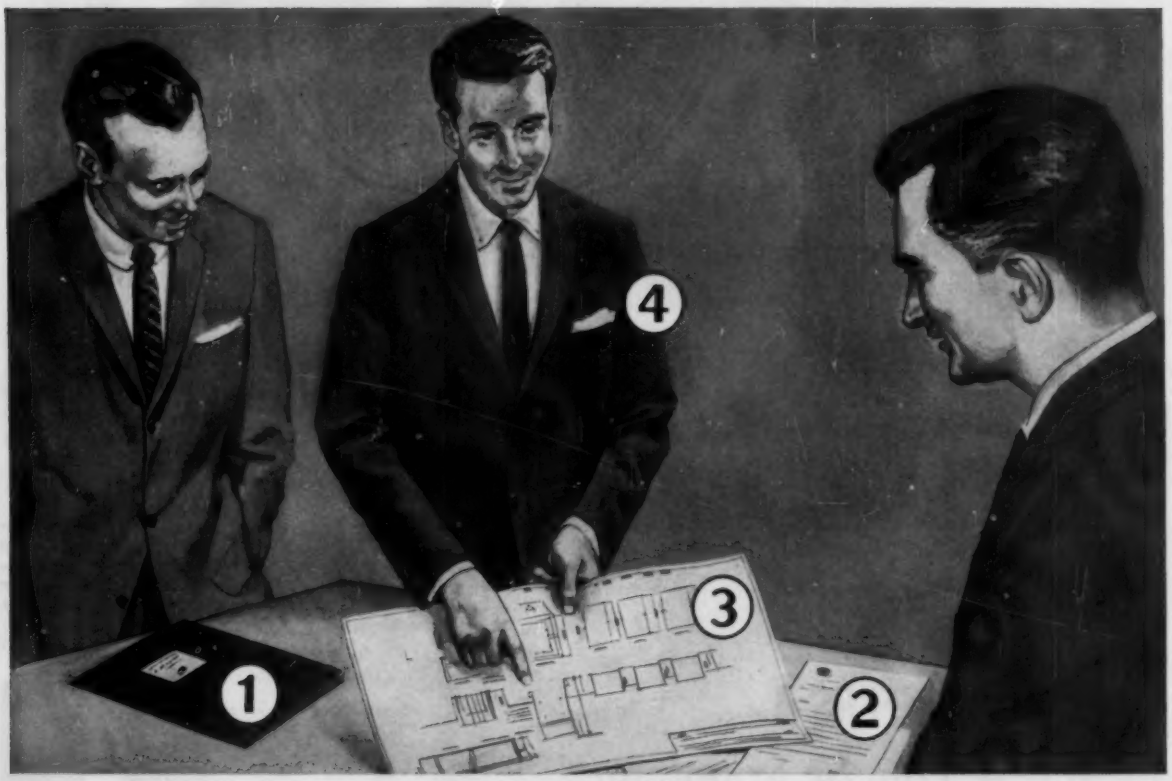


Semi-automatic loading and unloading equipment is available for single Ipsen heat treating units. With wheels and suitable track, single loaders and unloaders may serve a battery of furnaces.

AUTOMATIC *Ipsen* HEAT TREATING UNITS

IPSEN INDUSTRIES, INC. • 723 SOUTH MAIN STREET • ROCKFORD, ILLINOIS

Du Pont offers complete service in sodium hydride descaling



4 ways a Du Pont specialist can help you get started in hydride descaling

Call on Du Pont . . . prime producer of sodium . . . pioneer in hydride descaling

1. **He'll give you an outline** of a proposed descaling operation . . . including starting and operating chemical cost estimates.
2. **He'll provide know-how** based on 17 years of Du Pont research and experience in hydride descaling.
3. **He'll provide layout drawings** to help you select equipment and materials. Result: best use of your capital . . . savings in labor, chemicals and maintenance.
4. **He'll apply years of experience** in descaling. His starting up and continued on-the-job assistance helps eliminate many planning and construction problems.

Du Pont's complete service also helps solve descaling problems in our completely new Sales Technical lab, where you may observe your samples being processed, if you wish . . . adapt existing operations to new uses . . . convert from other processes to sodium hydride method. Users of this Du Pont service include the most prominent producers of stainless steel and other alloys. For the complete story, write Du Pont at one of the offices below.

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BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

ELECTROCHEMICALS DEPARTMENT
Sodium Products Division

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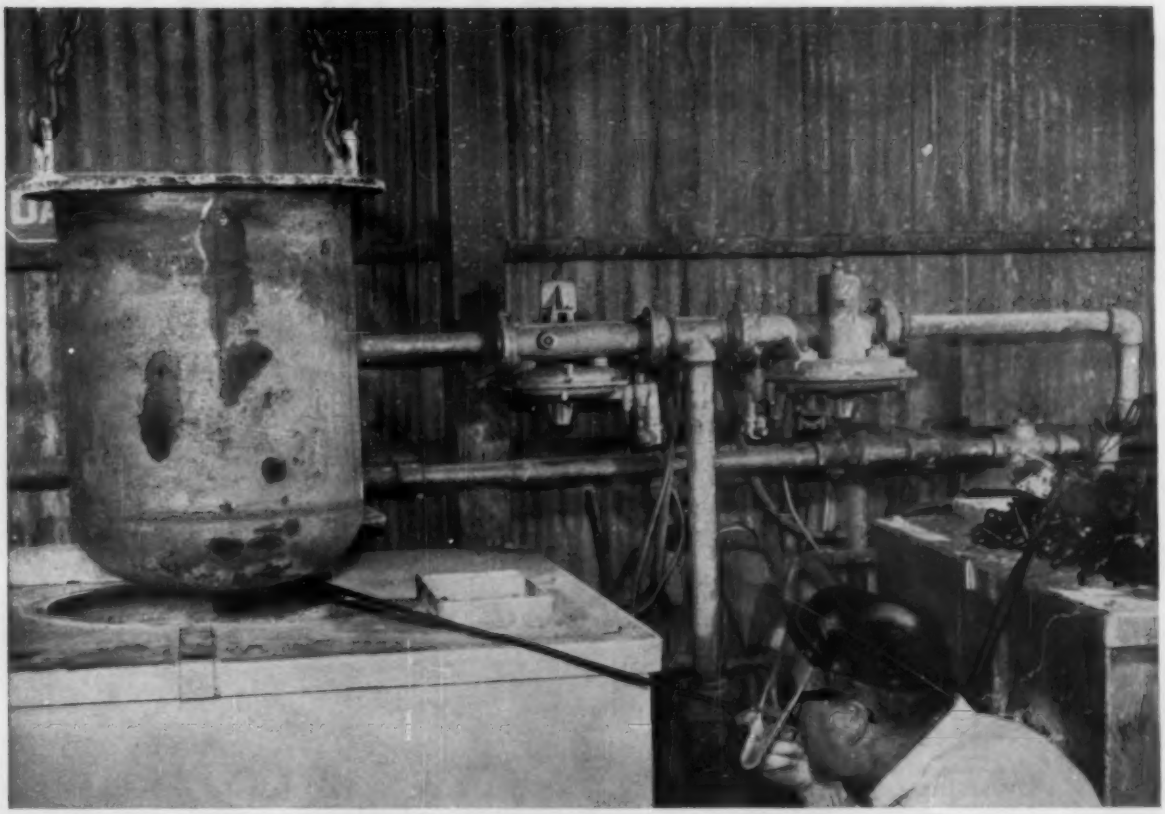


New as it looks, this Inconel neutral salt pot has already done 13,000 hours at 1,500°F

It doesn't show!

But this wrought Inconel* nickel-chromium alloy pot has been in 1500°F., 24-hour, 7-day-a-week, neutral salt bath service for well over 20 months . . . double the life of the best previous pots used by Valley Metal Treating Co. of Pomona, Calif.

Life is good for most Inconel alloy neutral salt pots

This performance is frankly outstanding. But wrought Inconel alloy pots have a growing reputation for long life in neutral salt service. Lives of 8000 hours or better are regularly reported.

Inconel alloy has proved one of the most reliable of all metals for other high temperature equipment, too . . . radiant tubes, baskets, muffles, retorts and fixtures.

In this equipment, Inconel alloy retains good strength characteristics up to 2000°F. Thermal shock and corrosion resistance are excellent, too.

Workability matches reliability

The usefulness of Inconel alloy is due as much to its workability as to its reliability. It can be readily formed, machined and welded by most fabricators.

Some of the many unusual ways Inconel alloy is being used to improve life of heat treating equipment are illustrated in the Inco booklet, "Keeping Costs Down When Temperatures Go Up". Let us put a copy in the mail for you.

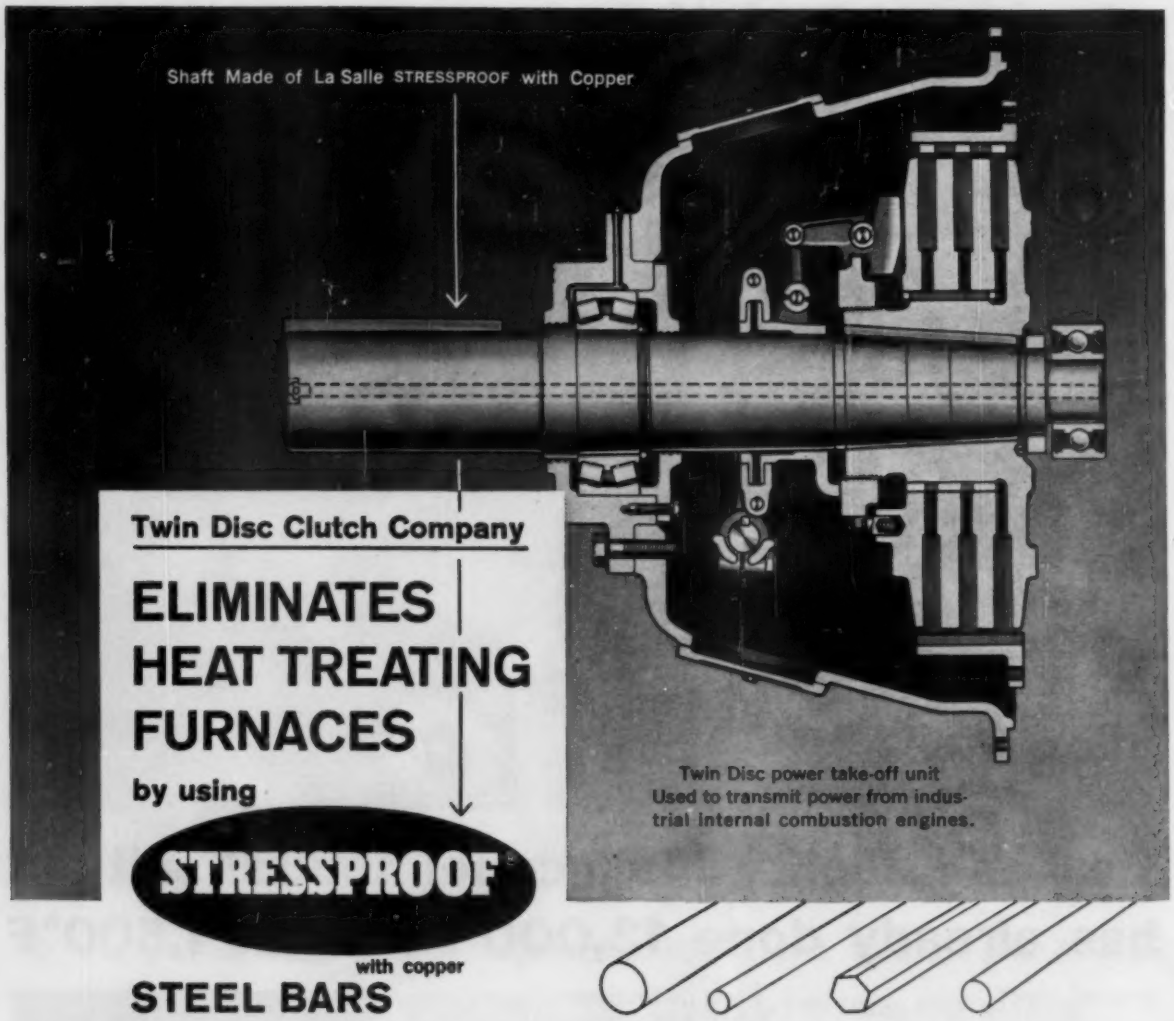
*Registered trademark

The INTERNATIONAL NICKEL COMPANY, Inc.

67 Wall St. INCO New York 5, N.Y.

Removing clevis shanks from Inconel alloy pot at Valley — Valley Metal Treating is the only commercial heat treater in the Pomona Valley region of California. Much of their work (primarily ferrous alloys) is treated in this neutral salt pot made by California Alloy Products Co. of Los Angeles. Pot is 24 inches deep, 18 inches in diameter. It was formed of 3/16" wrought Inconel sheet, then welded.

INCO NICKEL ALLOYS



Twin Disc power take-off unit
Used to transmit power from industrial internal combustion engines.

Twin Disc Clutch Company

ELIMINATES HEAT TREATING FURNACES

by using

STRESSPROOF

with copper

STEEL BARS

In Racine, Wisconsin, Twin Disc Clutch Co. saved money on a plant addition by eliminating heat treating furnaces . . . and they continue to save on part costs by using a material which needs no heat treatment . . . STRESSPROOF.

On the strength of over 15 years' experience with STRESSPROOF, Twin Disc knew they could cut their costs by purchasing this material which has the necessary properties in the bar.

They produce about 150 different models of power take-off shafts . . . see cross-section drawing. These shafts must possess great toughness and have the strength to take heavy loads. They must resist wear at the journals. Because one end of each shaft must be machined to individual customer specifications, machinability is important. Warpage after machining cannot be tolerated.

STRESSPROOF with copper fills these requirements on all counts because it has these four qualities in the bar: (1) Strength without heat treating. (2) Machinability (copper further improves machinability). (3) Excellent resistance to wear. (4) Minimum warpage.

By using STRESSPROOF, Twin Disc eliminates the cost of heat treating, cleaning and straightening. Working conditions are better . . . the plant is cleaner and cooler, and floor space requirements are less. Time and money consuming production steps are eliminated.

Twin Disc gets better parts at lower cost, and perhaps you can profit by their experience. Unless you have investigated STRESSPROOF recently, you may be overlooking worthwhile savings, especially since copper has now been added to improve machinability.

Available from your Steel Service Center.

La Salle STEEL COMPANY

1424 150th Street, Hammond, Indiana

Please send literature describing La Salle STRESSPROOF with copper.

name_____

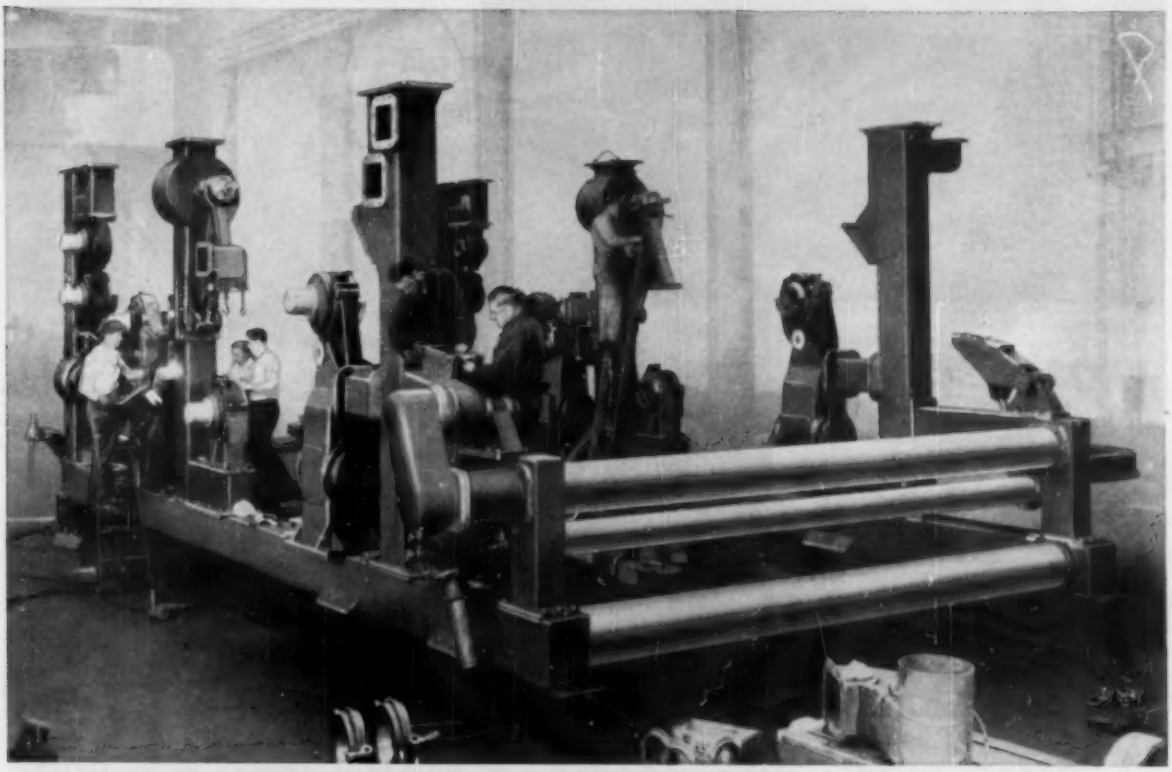
title_____

company_____

address_____

city_____ zone____ state_____

STEEL-WELD FABRICATION . . .



Part of a Large Paper Making Machine!

Use WELDED STEEL for 100% Predictability and Greater Strength with Reduced Weight!

The machine frame illustrated above is welded construction throughout. It is one of several subassemblies produced by Mahon for use in the construction of a large paper making machine. Each part was fabricated, machined, test assembled and matchmarked by Mahon for final assembly in the paper mill. This frame component, consisting of many weldments, is typical of the thousands of Steel-Weld Fabricated parts and assemblies produced by Mahon each year for manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment.

When you consider the use of weldments, you, too, will want to discuss your requirements with Mahon engineers; because, in the Mahon organization you will find a unique source for weldments or welded steel in any form . . . a fully responsible source with complete facilities for design engineering, fabricating, machining, assembling and handling.

See Sweet's Product Design File for information, or have a Mahon sales engineer call at your convenience.

THE R. C. MAHON COMPANY • Detroit 34, Michigan

SALES-ENGINEERING OFFICES in DETROIT, NEW YORK and CHICAGO

MAHON

NOW–Both available from Sylvania

High purity Tungsten and Molybdenum pellets

Give new control over purity, composition, production and price in vacuum melting

Tungsten as well as molybdenum is now available from Sylvania in pellet form. The constant purity and exact composition of the new pellets make it possible for vacuum melters to meet the most stringent alloy specifications, melt after melt. Minimum purity of the new tungsten pellets is 99.90% and typical purity is 99.94%.

The new Sylvania tungsten pellets as well as the molybdenum pellets promote substantial savings in vacuum melting production time. There is no need to analyze every batch, and calculations for correct additions of tungsten or molybdenum are simplified. In addition, the convenient size and shape of the pellets facilitate weighing and charging to the melt where they sink and mix quickly.

The dependable supply and stable price of Sylvania tungsten and molybdenum pellets mean that vacuum melting production schedules can be realistically planned on a long-range basis. Alloy price structures can also be maintained without concern for fluctuating raw material costs.

Contact Sylvania's Chemical and Metallurgical Division for further particulars on high-purity tungsten and molybdenum pellets.

Chemical Composition	Typical Composition: Tungsten Pellets	Typical Composition: Molybdenum Pellets
Tungsten, %	99.94	–
Molybdenum, %	0.050	99.85
Iron, %	0.003	0.010
Silicon Dioxide, %	0.003	0.020
Nickel, %	0.002	0.005
Aluminum, %	<0.001	0.005
Calcium, %	<0.001	0.050
Copper, %	<0.001	0.005
Magnesium, %	<0.001	0.050
Manganese, %	–	0.005
Chromium, %	–	0.001
Cobalt, %	–	<0.001
Lead, %	–	<0.001
Tin, %	–	<0.001
Density	14.0 g/cc	8.0 g/cc
Pellet Size	11/16" d x 3/8" h	11/16" d x 1/4" h

TUNGSTEN • MOLYBDENUM • CHEMICALS • PHOSPHORS • SEMICONDUCTORS

SYLVANIA

SYLVANIA ELECTRIC PRODUCTS INC.
Chemical and Metallurgical Division
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MOLY NEWS

CLIMAX MOLYBDENUM, 500 FIFTH AVENUE, NEW YORK 36, N. Y.

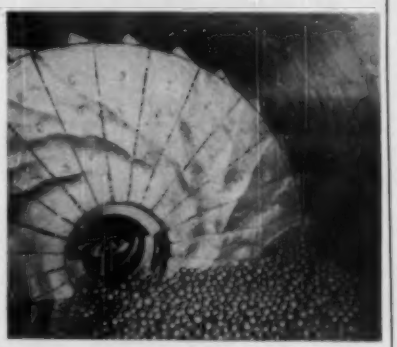
Chrome-Moly Steels Prove Ability To Resist Wear and Abrasion, Cut Costs

Can be Adapted to a Wide Range of Uses

To offset rising equipment and maintenance costs, the savings possible with wear-resistant alloy steels are receiving increasingly wide attention, in a growing number of industries.

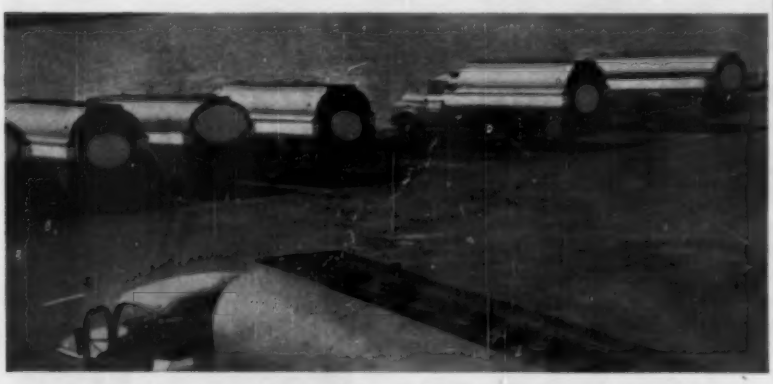
Two types of "Chrome-Moly" steels show exceptional resistance to abrasion and wear under toughest conditions. Both have substantially cut liner costs and shutdown time in grinding mills. Both are suitable for a variety of other industrial applications because they combine wear resistance, favorable first cost, freedom from premature failure by breakage or spalling, resistance to flow in service, consistently uniform performance and adaptability to specific designs.

The two types are Pearlitic (250-450 BHN) and Martensitic (450-700 BHN). Carbon and alloy contents and heat treatments of both types can be varied to suit specific applications.



Note that the spiral wear pattern is clockwise, even though the mill's rotation is counter-clockwise. Type 2 Martensitic steel is used here.

For an article on the use of Chrome-Moly steels, send for "How to Select Chrome-Moly Steels for Ball and Rod Mill Liners" by T. E. Norman, reprinted from Engineering and Mining Journal. Circle #1 on the coupon.



New Use For Super-Strength Structural Steels

Today, gasoline trailer tanks are built of super-strength structural steels for a good reason. The steels have high strength/weight ratios. This factor enables builders to design tanks that carry greater payloads and still meet legal gross weight limits. And the extra capacity pays for the higher trailer cost in a few months!

This use is only one of countless possibilities for utilizing the steels' minimum yield strengths of 55,000 to 150,000 psi . . . and their many other desirable properties. *For more information, including tradenames and compositions, ask for "Super-Strength Structural Steels." Circle #2.*

Sums Up Moly's Resistance to Corrosion

A new paper, "Corrosion Resistance of Molybdenum and Molybdenum-Base Alloys," based on published literature, summarizes moly's resistance to a number of corrosive media. It also lists the reference articles. For a copy of this paper, *circle #6.*

Molybdenum Improves Corrosion Resistance of Stainless Steels

Translated excerpts from two French articles discussing how moly improves the corrosion resistance of austenitic and austenitic-ferritic stainless steels are now available. *Circle #7.*

Special Steels Solve Hydrogen Sulphide Problem

Hydrogen sulphide in France's Lacq natural gas field brought up a metallurgical problem: the need for tubing meeting the N-80 strength requirements but with better resistance to sulphide stress corrosion than the conventional N-80 grade. Two such steels have been developed. One contains chromium, aluminum and molybdenum; the other contains chromium, molybdenum and vanadium.

For articles discussing both steels, send for "A Special N-80 Steel Tubing . . . " by Cauchois, Didier and Herzog, reprinted from *Corrosion*, and "Comments on new French N-80 Steels" published by Climax. *Circle #3.*

Vanadium in Low-Alloy, High-Temperature Steels

Molybdenum is a must in low-alloy, high-temperature steels. However, recent tests at the U.S. Naval Research Laboratory point up the role of Vanadium in such steels, and show the effect of variations in composition and treatment. Addition of Vanadium results in a better high-temperature alloy, but getting the improvement requires higher normalizing temperatures.

The advantages and limitations are described in an *Iron Age article*, "Higher Vanadium Improves Hot Strength of Low Alloy Steel," by Paul Shahinian and J. R. Lane. *For reprints, circle #4.*

New Cleaner Removes Surface Oxides From Moly Metal

A practical, low-temperature method of cleaning molybdenum has recently been developed. It is especially suitable for removing surface oxides prior to welding. The process involves two chemical baths: one at 150-180°F, the other at room temperature. *Digested from "Ryan Devises Molybdenum Cleaner," Ryan Aeronautical Company. For reprints, circle #5.*

Climax Molybdenum, Dept. 5
500 Fifth Avenue, New York 36, N. Y.

I'd like more information on:

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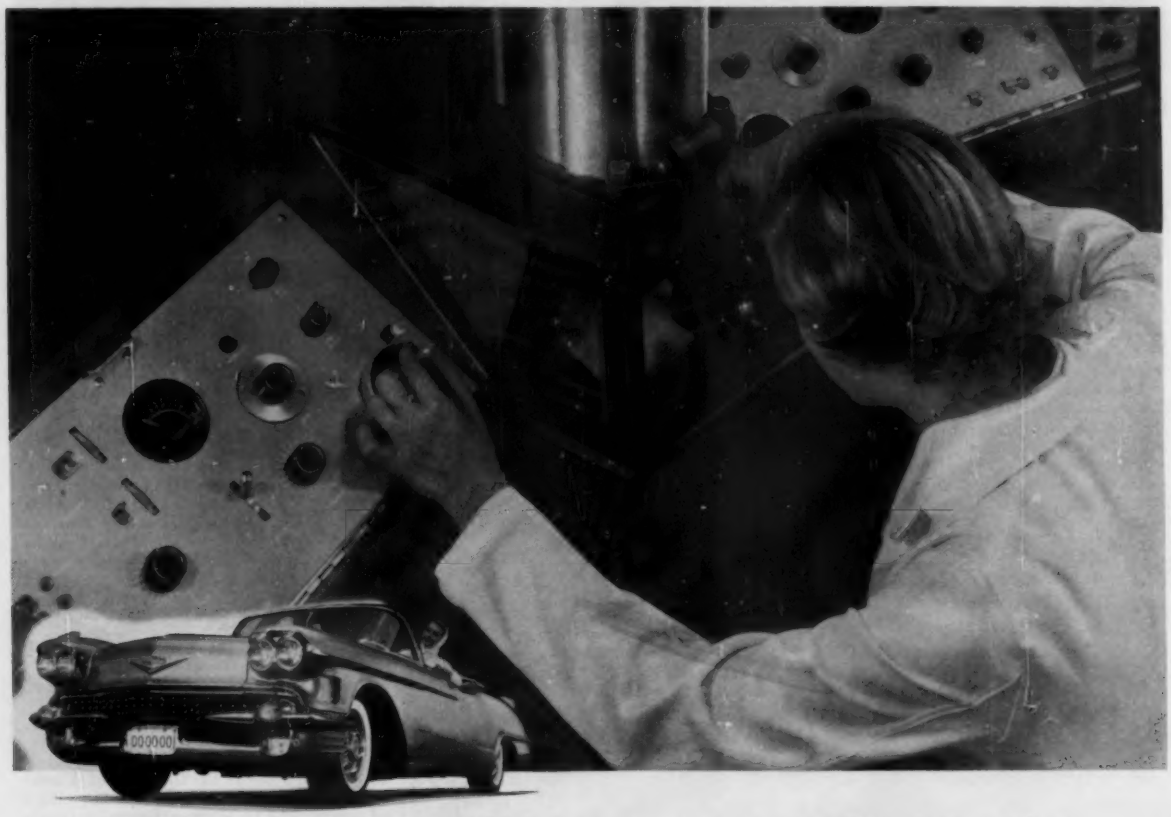
MASTERING THE MOLECULE . . . WITH ELECTRON MICROSCOPY

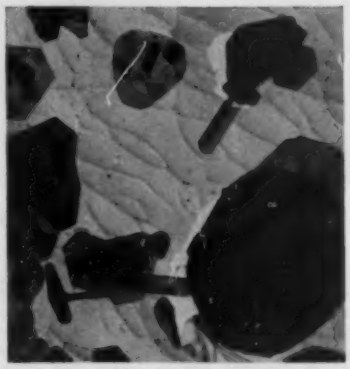


RCA Electron Microscope helps build better cars at General Motors

Automotive masterpieces have virtues that are more than "skin deep," thanks to basic research with the RCA Electron Microscope. At General Motors Technical Center in Detroit, studies using the instrument range in scope from determining deformation in crystalline solids to quality control problems in connection with heat-treated metals. Recently, GM researchers correlated the score resistance properties of an alloy used in bearings with the precipitation of silicon.

Micrographs, such as shown, indicated that optimum performance resulted when the aluminum-silicon-cadmium-bearing material was heat treated to precipitate the thin crystallites of silicon throughout the matrix. Particle size and distribution were studied by means of electron microscopy and positively identified by electron diffraction.

RCA Electron Microscopes are providing valuable information regarding size, shape and structure of particles smaller than 20 angstrom units. With the ability to produce direct electron image magnifications up to 200,000X, the RCA Electron Microscope is advancing man's knowledge in many fields, as diversified as automobiles and cell structures . . . chemicals and viruses. Installation supervision and contract service are available through the RCA Service Company.



Undissolved silicon (large opaque particles) and thin silicon plates in an aluminum matrix, magnification 12,000 diameters. (Micrograph courtesy General Motors Research Staff.)

For full particulars, write to RCA, Dept. E-72, Building 15-1, Camden, N.J.
In Canada: RCA VICTOR Company Limited, Montreal.

RADIO CORPORATION of AMERICA

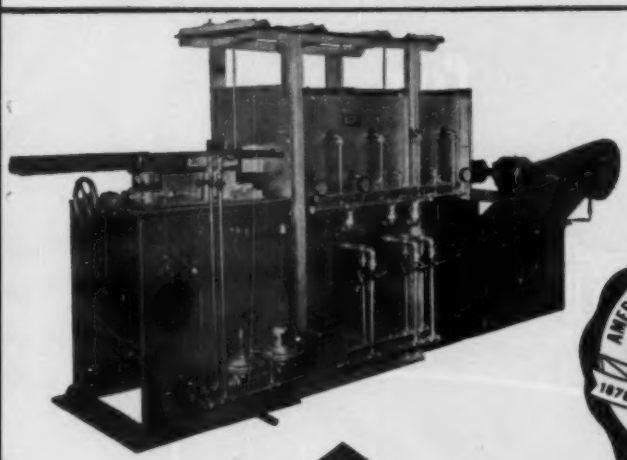
CAMDEN, N. J.

Trnk(s) ®

AGF FURNACES for STAINLESS

HARDENING ANNEALING BRAZING

CONTINUOUS TYPE OR SEMI-CONTINUOUS BATCH



AMERICAN GAS FURNACE CO. 80 YEARS OF PIONEERING 1878 1958 ELIZABETH, N. J.

AGF SERIES 50 PUSH THROUGH MUFFLE FURNACES

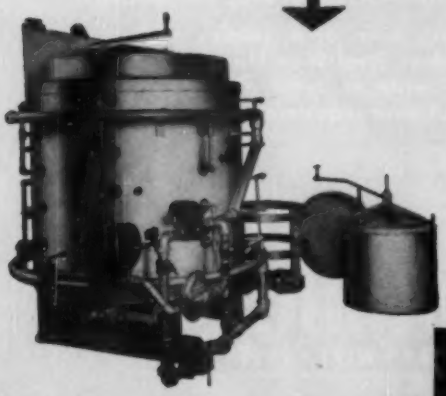
permit bright annealing, copper and alloy brazing, atmosphere hardening of regular and stainless steels — and in addition silver soldering or annealing of ferrous, non-ferrous or precious metals. Full range of sizes available.

AGF SHAKER HEARTH FURNACES

provide automatic continuous bright hardening and annealing of stainless steel parts. These versatile furnaces feature automatic quenching and positive atmosphere control. Can be used without modification for clean hardening or light case carburizing of steel parts.

Highly versatile AGF Bell Retort Furnaces

for atmopsphere work at lowest cost with a minimum use of floor space. The use of multiple removable bell retorts provides semi-continuous operation. In addition to bright stainless work, these flexible furnaces without modification can be used for nitriding, Ni-Carbing and carburizing. Available in laboratory and production sizes.



"AGF Metallurgists and Engineers will provide recommendations for your proper heat treating installation at no obligation".

The furnaces illustrated are merely indicative of the standard AGF furnace designs which include Tube Furnaces for wire and strip hardening and tempering; Rotary Retort Furnaces for reduction of oxides, as well as a complete line of standard industrial heating appliances ranging from burners to completely automatic heat treating installations.

WRITE FOR EQUIPMENT CATALOG 80-A. REPRESENTATIVES IN PRINCIPAL INDUSTRIAL AREAS.

AMERICAN GAS FURNACE CO

1002 LAFAYETTE STREET — ELIZABETH 4, N. J.

Announcing

NEW SOURCE

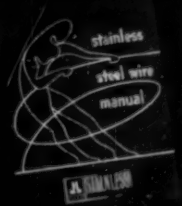
for

J & L Stainless Steel Division's New Wire Mill Offers Wide Range of Wire Sizes

The increasing use of stainless steel wire in new product development, old product improvement and for experimental purposes has placed a new responsibility on the manufacturer of quality stainless steel.

To meet this growing need, J & L Stainless Steel Division is pleased to announce the opening of its new wire mill . . . to make available stainless wire in a wide range of sizes, finishes and coatings.

For data regarding wire, its properties and uses, consult our Stainless Steel Wire Manual. For special applications write in detail giving complete information about your requirements.



Wire now for your copy of J & L's new Stainless Steel Wire Manual.

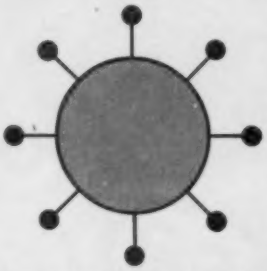
Improve your Products with . . .

J&L STEEL STAINLESS

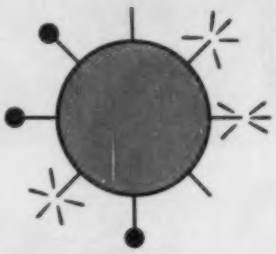
BAR • WIRE • SHEET • STRIP

Jones & Laughlin Steel Corporation • STAINLESS STEEL DIVISION • Box 4606, Detroit 34

Does the solvent you use "go sour," like this?



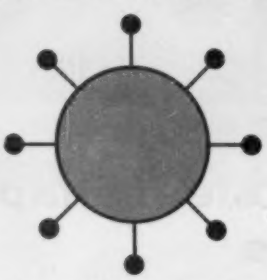
1. The trichlorethylene you use for degreasing metal is protected by a stabilizer (small circles) against heat, light, air, moisture, acids and active metals like aluminum.



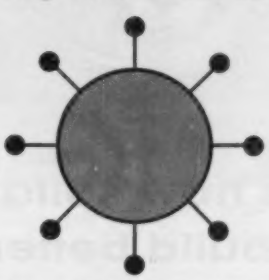
2. Ordinary stabilizers wear out or become depleted during normal use. With some solvents, you have to titrate your bath frequently, and may have to add fresh stabilizer.

3. When stabilizer wears out, your degreaser doesn't function properly. It may even stain metal parts instead of cleaning them. You have to clean out the "sour" bath.

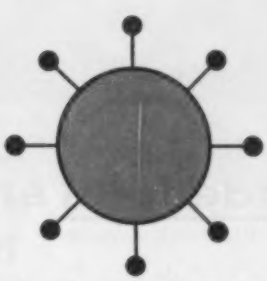
Use Nialk® TRICHLORethylene and get psp ... like this



1. You get full-time protection with NIALK stabilizer's unique action. Notice the difference between the next two diagrams and those above.



2. NIALK stabilizer does not wear out during normal use. It's always there, working. You never have to titrate your bath, or add fresh stabilizer.



3. Even after repeated distillations, you still have complete protection. All the stabilizer is active. Only NIALK has this **psp**—permanent STAYING power.

Why you pay less to degrease with Nialk® trichlorethylene

The drawings above demonstrate a difference—a big, cost-cutting difference—between NIALK trichlorethylene and conventional vapor-degreasing solvents.

NIALK has psp—permanent STAYING power—in its stabilizer. It's neutral, non-alkaline. You never have to replenish it.

psp for cheaper degreasing

You don't have to clean out your degreaser nearly so often with NIALK trichlorethylene. You can degrease many more parts between cleanouts.

The NIALK stabilizer actively retards formation of degradation products—cleanouts are easier, faster.

Get proof of Nialk's cheaper, safer degreasing

See for yourself how NIALK with psp remains stable, keeps cleaning efficiently long after other solvents have lost their punch. Write on your business letterhead for a resumé of comparative metallurgical tests on five leading brands.

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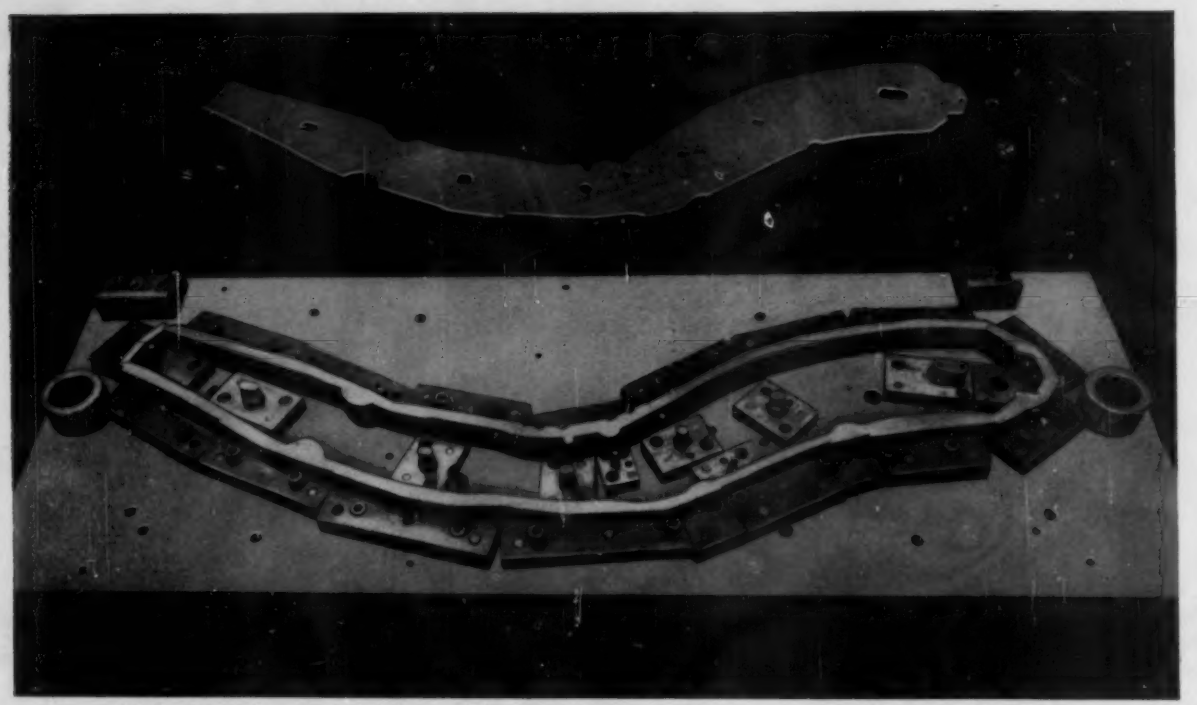


Midland-Ross die made of Uddeholm solid tool steel shapes, with resulting part — similar to die at ASTE Show

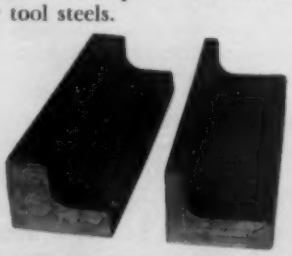
Uddeholm shows how solid tool steel shapes help build better dies

Die At Booth 330, ASTE Show Provides Good Example

Building better dies is getting a boost these days from the use of solid tool steel shapes. Case in point — a blanking and perforating die shown by Uddeholm at the coming ASTE Show in Philadelphia. Incorporated in the design of this die are Uddeholm's standard water-hardening H and J tool steel shapes — used in place of 2½" x 3½" rectangular stock. Midland-Ross Corp., Cleveland Div., one of the country's largest automotive frame manufacturers, uses this die to blank and perforate automobile X frames and component parts. Sheet and plate blanked by the die average ⅛" to ½" thick. On occasion it has also blanked material up to ⅝" thick.

Midland-Ross prefers the Uddeholm shapes because they are *solid tool steel throughout*. Any part of the shape can be used as a working surface. And their greater inherent strength eliminates any of the breathing action often resulting in composite sections. Uddeholm shapes are available, from warehouse stock, in either oil-hardening (SAE O1) or standard water-hardening (SAE W1) analysis. Supplied in 10-12 ft. random lengths, they provide great flexibility in making die sections to a wide variety of forms and lengths. See your Uddeholm sales representative for more information on Uddeholm's complete selection of fine, Swedish-quality tool steels.

Write For Tool Steel Stock List No. 12



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Harry Einsel, of Western Industrial X-ray Corp., tapes film holder to refinery pipe for emergency examination described below.

"Under any conditions,

you can count on Du Pont X-ray Film"

says Charles E. Smith, Vice President and General Manager of Western Industrial X-ray Corporation, Lubbock, Texas.

Western Industrial X-ray puts film to pretty rugged tests—and has found that Du Pont film comes through with flying colors.

With eight mobile x-ray units, the firm can go anywhere to radiograph such equipment as refinery machines, aircraft components, steam pipes, pipe lines and powerhouses. Under such a wide variety of conditions, Mr. Smith has found that "Du Pont film has the latitude, sensitivity and toughness to give good results *every time.*"

On one occasion, Mr. Smith was called on to make an emergency examination in a refinery. It was a hot, dry Texas summer day. "We had no time to pick up ice to cool our chemicals," he recalls. "So, we processed the films in solutions that were up to 88° F instead of the recommended 68° F. We cut the developing time and got very good radiographs—with no sign of reticulation."

Du Pont service, too, has impressed Mr. Smith. "Technical Representatives Don Nolte and Don Sands have done a lot for us. They're always ready to help, getting us film in a hurry and working with us on technical problems."

If your x-ray needs include film with quality and latitude, combined with the best technical service, call the nearest Du Pont Sales Office, or write Du Pont Photo Products Department, 2420 Nemours Building, Wilmington 98, Delaware. In Canada: Du Pont Company of Canada (1956) Limited, Toronto.

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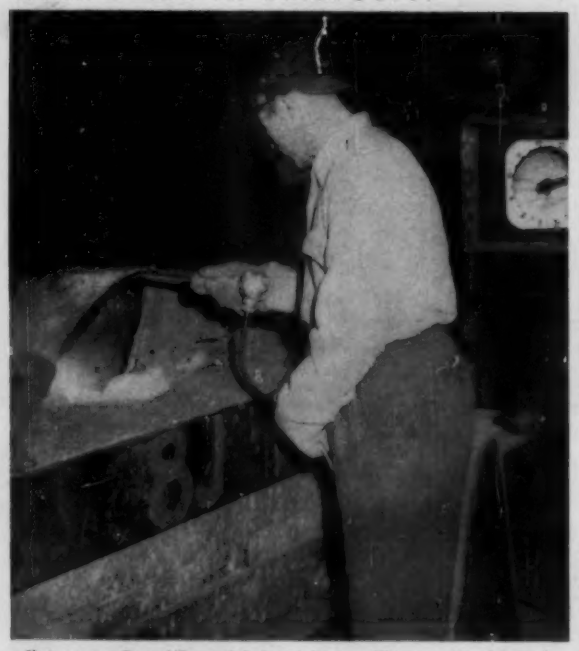

Photo courtesy General Thomas J. Rodman Laboratory, Watertown (Mass.) Arsenal.

NEW!

Immersion thermocouple for molten metals measures to 3200F

The new Bristol portable immersion-type thermocouple is designed for direct measurements in melts of both ferrous and non-ferrous metals. Simplicity and operating economy are its key features.

Rugged tubes give economy. Latest result of Bristol's continuous development program in instruments and accessories for pyrometry, the new thermocouple's durable protection tube can take up to 14 dips in molten steel at 2700 F to 3200 F. Metals of lower melting temperatures such as brass and aluminum will give far longer life. What's more, replacement of the protection tube, plus reasonable care, allows re-use of the platinum sensing element—most expensive part of the unit.

Standard and "high-speed" models. The standard model of the new thermocouple—full response 30-45 seconds—features a Bristol metal-ceramic (LT-1) secondary protection tube. A special "high-speed" model—response 15-20 seconds—has a single quartz protection tube with quick-change thumbscrew, designed for easy replacement.

STOCK PARTS CUT COSTS, SPEED SERVICE

All parts in the new molten metal thermocouple are stock parts—a product of Bristol's careful design and advanced manufacturing methods. Result: lower first cost due to production economies and faster delivery on replacement parts.

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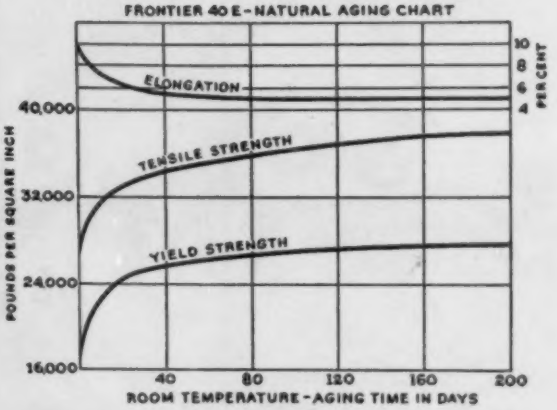

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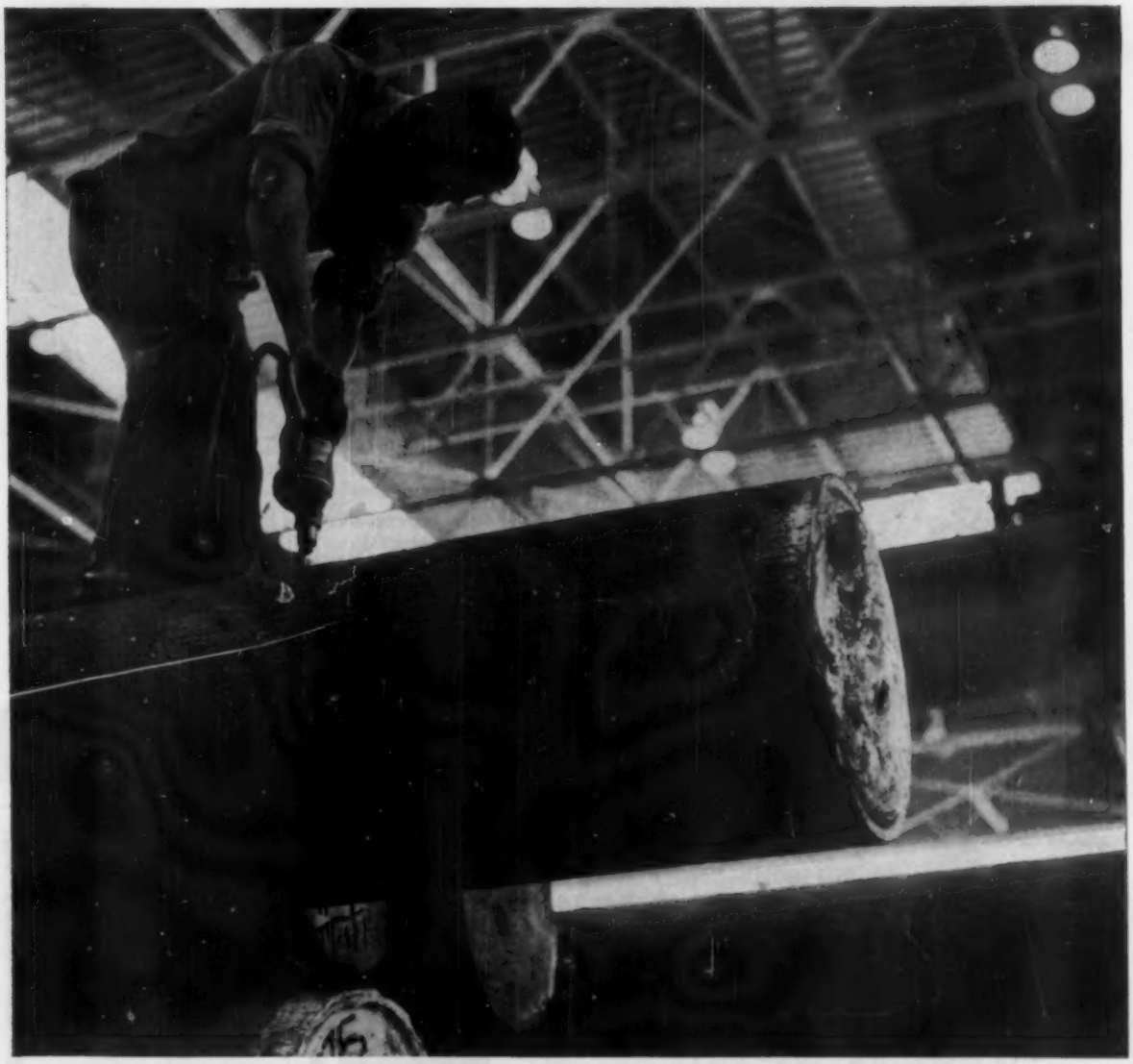

Kaiser Aluminum ingots being prepared for "homogenizing" in Gas-fired furnaces prior to extrusion into aircraft parts

GAS assures precision alloy extrusions at Kaiser Aluminum

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Again, Gas is used to heat the extruded shapes in a controlled atmosphere to impart the desired physical qualities in the alloys used. As in the melting process, Gas provides precise temperature control and close control of atmosphere within the furnace.

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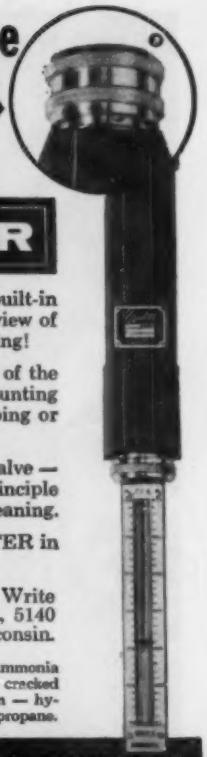

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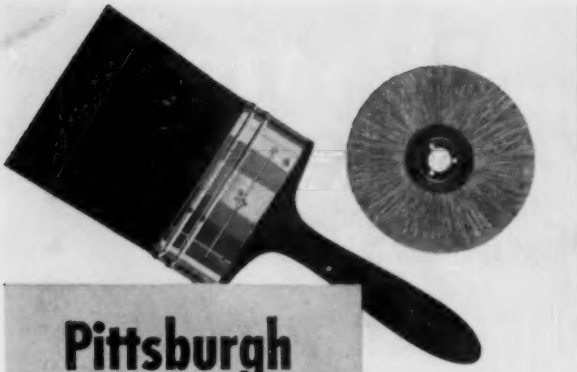

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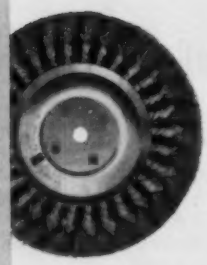

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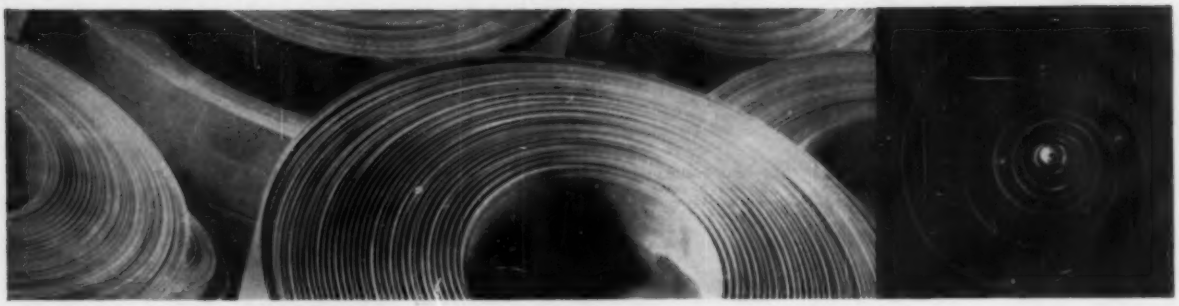

How they're using

Wallace Barnes Cold-rolled Specialty Steels

1. *In Three Drawing Stations*

The part shown in illustration one was made from .59 – .74% carbon steel in three drawing stations. From .70 – .80% carbon, this piece should have four or five drawing stations. The piece could be made from .90 – 1.05% carbon, but would require seven drawing stations with fully annealed steel.

2. *Blanked on 45° Angle*

The stamping shown in the second illustration was made from .70 – .80% carbon spring steel. It was blanked and pierced on a 45° angle, with small holes pierced to prevent fracture in later forming and bending. It was then given severe secondary forming. The small tab shows "orange peel" and probable fracture would occur if the part were formed from .90 – 1.05% carbon.

3. *All Flanging One Operation*

Our third part is a gun stamping made from .70 – .80% carbon with a sharp bend with the grain in one stroke of the press. Higher carbon will fracture due to its less ductile qualities.

4. *Thirteen Steps Progressive*

The fastener shown in the fourth illustration was made from the .59 – .74% carbon steel, the only spring steel which would take the bends and draws to which it is subjected here. All the higher carbon steels were rejected because they failed under the cold-work necessary to produce the two small extrusions. It took seven reductions to bring these extrusions within tolerance. There were thirteen steps total in the progressive die.

These examples show how proper steel selection may save operations and insure satisfactory performance. Among the many sizes and types of Wallace Barnes cold-rolled specialty steels is the right one for your application. Send for "Physical Property Charts" giving tensile strength and forming properties of Wallace Barnes tempered steels.

Wallace Barnes Steel Division

Bristol, Connecticut

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Metal Progress

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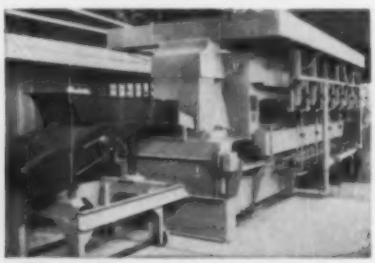

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